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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XII[th] SESSION (CAIRO, 1933).

QUESTION V:

Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

REPORT No. 3

(All countries except America, Great Britain, Dominions and Colonies, China, Japan, Belgium, Spain, France, Italy, Holland, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden),

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I. — Introduction.

We understand by « electrification of railways », in the meaning of Question V, the installation of electric traction on railway lines and sections of lines constituting or supplementing the system of one and the same administration, the character and type of operation of which correspond to those of the principal railways still mainly operated by steam in all countries except Switzerland. The urban and suburban railways of large towns are included in this category of railways. Small local and district railways, tourist railways in mountainous districts, tramways and underground railways are not considered as railways in the sense accepted in the foregoing.

The technical side of the electrification of railways has already been considered in various forms. In this connection, we shall merely state that the numerous instances of electrification already completed, in hand, projected or under consideration constitute a tan-

gible proof that the problem of electrification has been solved from the technical point of view. The existence of different practical systems of electrification distinguished by the nature of the current and the type of the equipment tend to facilitate the adaptation of electric traction to the working conditions of the railway and to the possibilities of supplying it with electric energy. There is no prospect of any new system of electrification which would be substantially better than the known systems, and it is scarcely possible to anticipate such a system. It is true that technical progress may still produce improvements of more or less importance, but such improvements may also be adopted in existing installations, and in any event in their extensions. One may also safely assert that, in its technical capacity, electric traction has surpassed steam traction. This superiority of electric traction resides, in short, in the central production of energy for locomotion and in the transmission of this energy practically in any powers and quantities according to the requirements of the moment to the motor vehicles, a transmission which can only be effected with electricity. The improvements which can still be made in steam locomotives and internal combustion engines will not be able to weaken seriously this superiority of electric traction.

The fact that it is just those administrations who have already installed electric traction on a large scale that are working out new plans for electrification, confirms the success obtained with this form of traction. Electrification is to the fore everywhere where steam traction is falling short, in one way or another, of the requirements of either the Administration or the public.

Whenever it is a question of substituting electric traction for steam traction on an existing line, and particularly on a homogeneous system, electrification is accompanied by expenses for the conversion of existing plant of the railway and is consequently more costly than the electrification of a new line.

The considerable capital required by such an extensive substitution places a heavy responsibility upon the administration. In fact, railways are undertakings which, without exception, should be managed and operated according to economic requirements in the real sense of the word.

State railways may, at the most, be guided by consideration of a national order. Each electrification should as a rule improve the « profit and loss » account of the railway and should not in any event be a charge on it. It ought at least to be possible to anticipate such an improvement.

Capital invested in electrification considerably increases the interest and depreciation charges of the railway. These charges must be offset by a reduction in the running expenses or by an increase in the receipts or by both together. On the other hand, however, it is possible with electrification to avoid or postpone considerable expenditure for the extension of stations, or the duplication of tracks and laying down new lines, an expenditure which would have become necessary had steam operation been retained.

For financial and technical reasons, large scale electrification of a railway system can only be carried out in successive stages over a period of greater or lesser length during which regular operation is interrupted. This interruption in the regularity of operation may give rise to difficulties of organisation and to suggestions which, however, compared with the economic question, remain secondary factors that may be obviated fairly easily.

Thus, the examination of electrification from the economic standpoint does

not merely consist of a comparison pure and simple between electric operation and steam operation, but it also covers a number of special considerations connected with the traffic capacity of the lines, the maintenance of the rolling stock and the fixed plant of the railway, the development of the traffic and improvements in the service, a knowledge of which is necessary in order to be able to elucidate the question. The problem is in general complex and difficult of solution, not only for electric operation which is projected, but also for that which is already in existence. The administration and engineers engaged on the problem know moreover from experience how difficult it is generally to shed light on all questions relating to railway economics.

The installation of each new isolated electrification, as also any extension of electrified railways, depend upon the direct or indirect advantages which may be anticipated.

Considering the present level of engineering, Question V thus reflects the problem of electrification. In an endeavour to elucidate it on the basis of the experience gained, the Reporters have drawn up a rather long questionnaire relating to the different aspects of the question. It was sent to the adherent Administrations who possess such electrified lines as would enable them to provide interesting information.

II. — The electric railways of the whole world.

The National Electric Light Association, of New York, has published in its periodical *Electrification of Steam Railroads,* interesting and fairly complete tables of all the electrified railways of the world, with the exception of tramways, local railways, American interurban railways in general and mountain tourist railways. From the number 079 for September 1930 we gather the following information which illustrates perfectly the state of development of the electrified railways in the whole world.

Electrically operated railways altogether possess a total length of about 16 800 km. (10 440 miles) of line. They are distributed among 90 administrations : 2 in Africa, 7 in Asia, 40 in Europe, 11 in South America, 21 in the United States and 6 in the other countries of North America. Of these,

21 administrations operate by electricity more than 160 km. (100 miles) of lines ;
6 administrations operate by electricity more than 800 km. (500 miles) of lines ;
3 administrations operate by electricity more than 1 600 km. (1 000 miles) of lines or more than 2 000 to 3 000 km. (1 243 to 1 864 miles) of track.

The separate instances of electrification carried out by the above-mentioned 90 administrations number 158. The number of instances of the extension of electrified lines is relatively large, and a fact which must be pointed out is that it is just the important electrified systems, such as those of the German National Railway Company, the Swiss Federal Railways and the Italian State Railways which are being extended. The more important of the new electrifications is that of the Pennsylvania Railroad extending over a length of about 1 100 km. (683.5 miles) of line and 4 000 km. (2 500 miles) of track.

The reasons, considerations and objects which, according to the above-mentioned publication, have led the administrations to electrify all or part of their railways may be summed up as follows :

13 instances of electrification in virtue of decrees or contracts with the public authorities tending to abolish smoke in towns and inhabited areas;
33 on account of tunnels;

48 on account of steep gradients;
3 to meet the traffic on overloaded lines or at congested terminal points;
4 to facilitate working at terminal points;
6 with a view to increasing speed;
45 with a view to increasing the capacity of the railway;
14 with a view to increasing the number of trains;
12 with a view to improving suburban service;
27 with a view to reducing the consumption, and in particular the importation, of coal;
9 due to the high price of coal;
1 due to the low price of water power;
3 due to the lack of feed water;
2 with a view to utilising cheap local lignite;
24 with a view to utilising hydraulic power;
4 for reasons of a technical character relating to connected electric railways;
1 as a trial;
13 with a view to developing traffic;
8 to reduce running expenses;
8 for reasons affecting national politics;
14 as a result of considerations affecting national economics.

The instances of electrification caused by the complete absence of coal or by its scarceness or dearness, or by the necessity for importing it and, conjointly, by the utilisation of water power affect a length of about 7 900 km. (4 910 miles) of line or 14 400 km. (8 950 miles) of track, representing 47 % of the total length of about 16 800 km. (10 440 miles) of line. Of these 7 900 km. (4 910 miles) of line, 2 300 km. (1 430 miles), or 4 900 km. (3 045 miles) of track have been electrified for reasons essentially concerning national politics.

This summary shows that the character and working conditions of the railways have played an overwhelming part in electrification, while the instances in which economic considerations have chiefly been concerned are relatively few in number. National politics have been the determining factor in a few cases only, but it is precisely in those cases that electrification has affected a considerable length of line. Extensive electrification which has not been occasioned by technical necessities is principally to be found in countries deprived of coal deposits but rich in water power. Such electrification chiefly affects State undertakings comprising lines on which the traffic is of a considerably greater volume than the average for the railways of the world.

According to the above-mentioned tables, the objects aimed at by the various administrations by means of electrification appear to have been attained in every case, even when this has not been mentioned expressly. Although, in a few isolated districts there has been a change in system, no instance is mentioned in which a return has been made to steam traction after electrification.

These general statements permit one to conclude that the existing electrified railways are everywhere satisfactory, from both the technical and economic points of view.

The first instances of electrification are already old. They were isolated and their number increased slowly. Progress in electrification was not manifest until much later, principally in the post-war period. In comparison with the extent of the railways of the world having a total length of line of about 1 000 000 km. (621 400 miles), it will be noted that the 16 800 km. (10 440 miles) of line at present electrified only form a moderate portion, not even attaining 2 %. Having regard to this, how can this progress in electrification be qualified ? It cannot be stated definitely whether it has been rapid, moderate or slow. The same reserve is imposed with regard to future electrification. The most that can be said is that electrification dictated by purely technical reasons will be carried out sooner or

later, while in fresh instances, electrification will only be effected where it will surely procure economic advantages.

III. — Electrification in the participating countries.

By «participating countries» is understood those countries possessing electric railways of the category in question, the administrations of which have sent us their replies to the questionnaire. These countries are Germany, Czechoslovakia and Switzerland.

The participant administrations of these three countries are :

Germany : German State Railway Company;

Czechoslovakia : State Railways ;

Switzerland : Federal Railways ;
Bernese Alps Railways (B.L.S.) ;
The Rhætian Railways.

Two other countries, Austria and Hungary, which belong geographically to the group of participants but are not represented in the Association by an administration, likewise possess interesting electric railways In order to be more complete, we asked the Austrian Federal Railways and the Hungarian State Railways to provide us with information regarding their electrified railways, which they were kind enough to do [1].

Apart from the electric railways of the three administrations referred to, Switzerland has a number of small electric railways. Those belonging to administrations who are members of the Association are few in number. These administrations have not replied to the questionnaire, since they considered that their railway was too small to have provided statistical and economic information capable of affording any interest.

Finally, we shall mention hereinafter the information we have received from countries in which electrification is under consideration :

In Bulgaria, electrification is under consideration and is meeting with financial difficulties. Fuel is not too expensive, so that from the economic point of view there is no great necessity for electrification.

In Poland, electrification of the railway centre of Warsaw is being considered. It is thought that a decision will be made before 1933.

In Serbia, electrification still remains a matter for consideration.

We shall now consider the electric railways in the different participating countries :

Germany.

The German State Railway Company is the only railway company in Germany to have electrified in the meaning of Question V. The state of its electric railways is shown in table I, of the Appendix, where it will be seen that there are :

2 typical instances of the electrification of urban and suburban railways, that of the Hamburg railways with 33 km. (20.5 miles) of line and that of the Berlin railways with 236 km. (146.6 miles) of line ;

3 instances of extensive electrification of ordinary line, one in Silesia with 348 km. (216.2 miles) of line, one in the Central Region with 191 km. (118.7 miles) of line and one in Bavaria with 733 km. (455.5 miles) of line, and finally

1 instance of electrification on a small scale, that of the « Wiesental » railway with 48 km. (29.8 miles) of line.

The electrification in the two first instances of Hamburg and Berlin was carried out in anticipation of the de-

[1] The Austrian Federal Railways and the Hungarian State Railways are now members of the *International Railway Congress Association*.

velopment of the urban and suburban traffic. For this reason also, it is intended to extend the electrified system of the Berlin railways.

Electrification in the Central Region and in Silesia was carried out in order to utilise *in situ* lignites which cannot be used for firing locomotives.

In regard to the electrification in Bavaria, it was a question of utilising the water power of the country instead of coal which came from a distance. The present extension of the electrification of the Bavarian railways affects the Augsburg-Stuttgart line 220 km. (136.7 miles) in length, comprising 690 km. (428.7 miles) of track. Another extension affecting the Central Region and Bavaria is also planned for the Munich-Nuremberg-Berlin line.

Austria.

The state of electrification in Austria is shown in Table II of the appendix. The reasons for this electrification are various, namely : increase in speed, abolition of smoke in the numerous tunnels and principally the utilisation of the water power of the country in replacement of the coal imported. The electrification has been undertaken since the war by virtue of the Acts of 23 July 1921 and 16 July 1925, and has been assisted, in the first place, by the high price of coal imported during the period immediately following the war. No electrification is actually in progress at the present time, but some lines are to be electrified as soon as the financial situation of the country improves. These lines are :

Vienna-Salzburg . . .	314 km. (195.1 miles)
Vienna-Graz	275 km. (170.8 miles)
Vienna-Strass-Sommerein	72 km. (44.7 miles)
Schwarzach-St. Veich-Spittal-Millstättersee	81 km. (50.3 miles)
Total . . .	743 km. (461.7 miles)

Czechoslovakia.

In Czechoslovakia electrification is still restricted to the stations and tunnels of Prague. Its extension to the lines terminating in these stations is being considered, but has not yet been commenced.

Hungary.

Hungary has only one trial electrification on a length of 9.5 km. (6.2 miles). The power for traction is obtained in the form of single-phase current from one of the phases of the three-phase industrial network, and is re-transformed into three-phase current on the locomotive by the Kandò system. The extension of this electrification from Budapest to Kamàron is under construction and its extension to Hegyeshalom has been planned.

Switzerland.

The features of the electrified lines of the Swiss administrations that have replied to the questionnaire are contained in table II of the appendix. Proportionately, Switzerland is the country where electrification has advanced the most, for reasons peculiar to the country. Switzerland has neither coal nor any other fuel suitable for railway operation. Its configuration being largely mountainous causes the railways to have a number of long and steep gradients and many tunnels. In proportion to its area, Switzerland is rich in water power, the utilisation of which is considerably facilitated and promoted by the numerous and favourable opportunities afforded by the country for the provision of large capacity reservoirs combined with high heads. In normal times, Switzerland imports many more commodities than she exports, so that the reduction of the coal imports and the utilisation of water power assume a considerable importance in her national economy. This became evident when, during the

war, coal became excessively dear and could only be obtained with great difficulty.

In 1906, the Federal Railways electrified the Simplon tunnel of 20 km. (12.4 miles) in order to eliminate the considerable inconveniences and the dangers arising from smoke and steam. This was an instance of tunnel electrification dictated by purely technical considerations.

Even before the war, the Federal Railways decided to electrify the Gothard line from Bellinzona to Erstfeld, a section having two watersheds with a long and steep gradient on either side and numerous tunnels of an exceptionally great total length, the chief of which measuring 15 km. (9.3 miles). The construction of this electrification was delayed by the war. The opening of the electric line through the Gothard took place in December 1920. The scarcity of coal prevailing at this time started a national campaign in favour of the electrification of the Federal Railways in order to render their operation independent of the importation of coal. A programme was drawn up according to which all the railway system ought to be electrified in 30 years. In 1923, a new electrification programme was drawn up for the accelerated electrification of a total of 1 134 km. (705 miles), up to the end of 1928. The intention of this measure was, apart from the original aims, to relieve unemployment. The people and the Parliament considered the electrification of the largest possible number of railways as coming within the national interest.

By virtue of a Federal law passed in 1919 and still in force, the Federation grants its financial support to private railways who are able to improve the economic efficiency of their operation by the installation of electric traction. More than a dozen railway companies have thus obtained the financial support of the State. This support consists in the provision of half the capital for electrification on condition that the regions and localities affected procure the other half. The electrification debt is placed in front of all the other debts of the railway in question. The rate of interest is as a rule 4 % to which is added 1 % for depreciation. In the general opinion, this law has given every satisfaction. It shows that electrification in Switzerland corresponds to the national politics.

The Bernese Alps Railway Company, Berne - Lœtschberg - Simplon, electrified the Lœtschberg line even before the war. This line has a tunnel 15 km. (9.3 miles) long and long slopes, having a maximum gradient of 1 in 37. This company has since electrified most of the lines operated by it, but belonging to other companies.

Although the Rhætian Railways are narrow gauge, their extent and character are such that they may be called, not secondary railways, but principal railways on a small scale. In 1911, they electrified a newly constructed line and since 1916 they have continued the electrification of all the systems of 277 km. (172 miles) of line.

In 1929, the Federal Railways fixed a programme for the extension of their electrification. This programme comprises 504 km. (313 miles) of which 76 km. (47 miles) are operated at present by electricity. The electrification of 70 km. (43.5 miles) is in course of construction, so that according to this programme, 358 km. (223 miles) will still be electrified and 693 km. (430 miles) will remain operated by steam.

Table III (Appendix) shows all the Swiss railways operated by steam and by electricity with the sole exception of tramways. It affords a certain amount of interest by reason of the important position occupied, in the railways of Switzerland, by the large number of small railway companies when taken together. Of the standard gauge railways,

59.7 % of the lines are electrified and comprise 85 % of their traffic expressed in gross ton-kilometres hauled, which shows that the electrically operated lines comprise, among others, the lines with heavy traffic. The proportion of narrow-gauge electric railways is still greater, attaining 79.4 %. They comprise 84 % of the traffic, that is, substantially the same proportion as the standard-gauge railways. With respect to the entire system of railways, 65 % of the lines are electrified and represent 85 % of the traffic.

IV. — Comparison between electric and steam operation from the economic point of view.

In most cases, electrification of the railway implies the substitution of electric traction for steam traction. The economic success of electrification consists therefore in the economic gain which can be procured as compared with maintaining steam operation. For equal receipts for the railway, this gain should result from electric operation being less costly than steam operation. In the contrary case, electric operation ought to increase the receipts in proportion to the additional expenditure. The gain will of course be more sure when electric traction has the effect of reducing the working expenses and increasing the receipts at the same time.

The increase in the receipts is a matter of experience, foresight and speculation. It is a very uncertain mathematical factor where electrification is concerned. In the case of electrification which has already been carried out, this increase in receipts is difficult to determine and more often can only be estimated.

In order to be able to make a comparison, it is necessary to know or determine the cost of electric operation, as well as that of steam operation. Before electrification, the cost of electric operation can only be calculated on the basis of experience gained elsewhere, whereas the cost of the existing steam operation is or ought to be known. After electrification, the actual cost of electric operation is or ought to be known, as well as that of the earlier steam operation in existence before electrification, and this latter cost should be adjusted to the working conditions created in the meantime. This is difficult when the economic circumstances, technical progress and measures of reorganisation have changed considerably the working conditions and there is no part of the railway or no other railway which is operated by steam, and is similar and comparable to the undertaking in question.

The problem of continuity in the normal operation of railways and the political and economic events occurring during the years of the war and afterwards have very particularly increased the difficulties of estimating the comparative cost of the steam operation abolished during that time. These considerable difficulties are experienced, for example, by the Austrian Federal Railways, the Swiss Federal Railways and the Bernese Alps Railways, who electrified during and immediately after the war.

This will show how difficult and uncertain it is to make a comparison when extensive electrification is carried out by stages covering a number of years.

Comparison between electric and steam operation only affords a relative interest in regard to the electrification of tunnels or urban and suburban railways. In the case of the electrification of a tunnel, the financial question is of relatively slight and secondary importance on account of the necessity to electrify for abolishing the dangers and inconveniences inherent to smoke and steam in a relatively very small part of the railway in question. In the case of the electrification of an urban and sub-

urban railway, the chief objects of electric traction are to develop the traffic, bring passengers to the railway and increase the receipts. It also assumes a great importance in regard to the indirect advantages resulting, *inter alia*, from the abolition of smoke in the neighbourhoods of large towns. As a rule, the financial question only plays a subsidiary part, considering that, in this case also, only a small part of the railway system in question is affected. It should be noted that it is practically impossible to provide for such a railway a steam operation which could be compared exactly with electric operation.

The comparison of the working expenses demands a wider acceptance of the cost of working as admitted in the « working accounts ». The latter should in particular be debited with the expenses relating to the capital expenditure. It is a peculiarity of electric operation that it reduces the real working expenses while increasing those relating to interest and depreciation by the investment of fresh capital.

Except when it is a question of tunnels or urban and suburban railways, all the instances of electrification show actual working expenses lower than those of the corresponding steam operation. Consequently, electrification means so to speak nothing less than an economic gain for the working account of the railway. With regard to the « profit and loss » account, electrification attains its economic object when the economies effected on the working expenses are greater than the additional expenses arising out of the capital expended for electrification.

Electrification is almost always accompanied by an increase in the length of run and the weight of the trains, and increase in the speed. The question arises as to whether the comparative hypothetical steam operation should relate to the same traffic capacities or up to what point it should approach electric operation. According to the answer to this question, the hypothetical steam operation will imply an increase in the number of locomotives, the acquisition of better engines, etc., and in consequence also an increase in capital.

Electrification always increases the traffic capacity of the railway. Due to this fact, it permits the extension of stations, duplication of track and the construction of new lines to be obviated or at least postponed for some time. Consequently, it may mean a saving of capital and hence also of interest and depreciation charges.

The advantages mentioned in Chapters II and III, but which are not visible in the railway accounts, are not taken into account despite their undeniable value and the decisive part they may have played. The administrations cannot enter them into the account. They would amend the comparison considerably, in favour, of course, of electric operation.

It follows from the considerations set forth that a general comparison between the different systems of operation is impossible because of the diversity of the cases, and that comparison in a concrete case is a problem which is still rather difficult. To the difficulties of the problem are added those inherent to any economic investigation of railway operation in general.

It is a mistake to believe that the success of electrification in general or of electrification in particular can be or ought to be determined so to speak mathematically. However, it is possible to draw up a scheme of comparison for the general case and to indicate the method of determining and dealing with the various items. Here again, however, a difficulty arises on account of the diversity of the methods employed by the administrations for collecting and utilising statistical information.

In Chapter V we shall return to the

arithmetical comparison of electric and steam operation, wether it concerns the electric operation and steam operation of one and the same railway, or the electric operation of two different railways or the steam operation of two different railways.

The known steam undertaking is most frequently something approaching the projected or constructed electric undertaking. The comparison between the electric and steam operation of one and the same administration would be easier if the latter possessed, in addition to its electrical undertaking, a steam undertaking similar in the more important points, and if most of the items for comparison could be obtained from statistics for each undertaking separately. This does not appear to be possible for any administration. Electric operation always relates to a portion of the railway on which steam operation was becoming unprofitable (mountain lines), or on which it was particularly profitable (lines with heavy traffic and regular profile) ; only exceptionally does it relate to lines with little traffic, and then only if the electrification of the latter is closely bound up with the principal electrification. Due to this fact, the electrified section of the railway possesses a structure and character differing from that of the railway as a whole and the non-electrified section, or the whole previous railway system of the same administration. If therefore, statistics provided strictly speaking the items for comparison for the two types of operation, these items would be more doubtful, the greater effectively or relatively the electrified section.

Of the member administrations, the German State Railway Company alone possesses in its Railway system which is still steam-operated, sections which, with regard to gradients, volume of the traffic and its distribution among the various categories, appear to be sufficiently similar to the electrified lines of Central Germany to enable a comparison to be made between the two types of operation, on the basis of experience gained at one and the same period. However, since the particular features of steam operation for the section capable of comparison cannot be deduced from the statistics, they had to be collected expressly.

The German State Railway Company justly point out in their reply that the generalisation of the results of a special enquiry and their application to other sections of the railway, even if these are similar, are uncertain, and can only be made with considerable caution, on account of important features of operation which are concealed under an apparent similarity. They have prepared a similar economic comparison between the two types of operation by exact and scientific instructions based on a detailed enquiry expressly made for the purpose, so that the result of their investigation may be looked forward to with the greatest interest. We are of the opinion that, here again, it will not be possible to find all the statistical items necessary for a comparison between complete electric operation and complete steam operation, that is to say, between the corresponding average real values obtained in the same way, despite the fact that the extent of the existing steam operated system would permit a section of it to be taken out for comparison, on the basis of a sufficient similarity, with the electrified section of the same administration.

Considering that the decisive values for electrification can be deduced neither from statistics nor from special enquiries, and at all events, not exactly, we are of the opinion according to which the general impression that the effects of electrification leave on the specialist of the administration who has the required account of the electric operation and the old steam operation, as well as of similar instances of steam

operation, is a less appreciable determinative than the result of an arithmetical comparison, based on statistics and special investigations. This opinion may also be grounded on the fact that of the numerous administrations who have electrified or are still electrifying, very few on the whole have published anything like thorough comparisons between the two types of operation.

Speaking generally, electrification has actually been brought about by the improvements in operation which electric traction alone is capable of effecting in one important respect or in others mentioned and generally recognised, and in some cases in connection with considerations of a character affecting national politics. Electrification implies fresh capital expenditure, just as any other important improvement in operation, such as : the acquisition of more powerful locomotives, more comfortable passenger coaches, reconstruction and extension of stations, duplication of tracks, etc. The capital thus invested is in most cases unable to produce a saving or any other immediate gain, but it ought to find a return in the development of the traffic and the operating conditions.

V. — Arithmetical comparison between electric and steam operation from the economic point of view.

In pointing out the difficulties and uncertainties of the arithmetical comparison between two types of operation, it has not at all been our intention to detract from the interest afforded by this comparison. On the contrary, we consider that extensive electrically operated systems should be compared arithmetically with the steam operated systems they have replaced, so as to shed more light on this question and to facilitate the solution of fresh problems of electrification. The more extensive the electrification, the better are we able to draw economic conclusions regarding electric operation in general. It comprises more lines on which steam traction by no means threatened to be insufficient and which consequently, were not yet ready for electrification. Extensive electric undertakings comprise many lines on which electricity and steam competed so to speak on an equal footing and on which electrification was chiefly decided by considerations relating to economy of operation, railway policy and national economy, rather than by technical reasons.

Extensive electrification demands a considerable capital, the expenses of which should, by reason of their importance, be considered exactly. For this purpose, it is necessary to take into account the capital which would have been necessary for the improvement of the steam operation if this had been retained. The economic comparison between the two types of operation is difficult and complicated in the case of extensive electrification. It becomes all the more so as the technical advantages of electric traction diminish or if steam traction would not have been inadequate enough.

In what follows, we shall endeavour to draw up a scheme of comparison, from the economic point of view, between the two types of operation, and to set forth the decisive considerations, principally with a view to inducing a discussion on this subject. For this purpose, we will refer to a rather general or complete, but not unnecessarily complicated case, so that the scheme of comparison for actual cases will be simpler, in one respect or another, irrespective of the particular complications of each case.

It is without doubt superfluous to show here that arithmetical comparison should, on the one hand, be based on a sufficiently stable electric undertaking, with which precise experience, covering several years has been gained and on the other hand, on a steam undertaking comprising

the same section of the railway system under consideration. This steam undertaking is necessarily hypothetical. Before electrification, it was comprised without distinction in the steam operation of the entire railway and was not the subject of particular statistics. Consequently, in the general sense, it is not known in itself like the electric undertaking. Nevertheless, it may be established on the basis of experience gained previously on the entire railway, and since that time, on the non-electrified section, as well as on the basis of experience gained, in general, in steam operation.

As a correction for electric operation, we shall assume that steam traction would not yet have failed anywhere in the electrified section of the railway system, and that it would still be sufficient, for example, because no increase in traffic would have been anticipated for the next few years.

We shall imagine electric operation on 500 to 1 500 km. of line, with a traffic of 4 to 12 billions of gross ton-kilometres, which would be developed in stages within a space of 8 to 10 years and which would have been established statistically for several years. We assume that such electric operation is not so perfect as it might have been had the administration, from the start, had all the experience it possesses today, and finally we shall suppose the same work expressed in gross ton-kilometres for the electric operation and for the comparative steam operation. The numbers of train-kilometres, locomotive-kilometres and locomotives which such operation comprises are indispensable for calculating the cost of the comparative steam operation.

The statistics for the old steam operation of the entire railway system and the present operation of the non-electrified section do not provide these figures, and as we have just seen, they have to be determined, which can only be done by making assumptions and estimations. It is essential to make the comparison on the basis of the last annual statistics relating to electric traction.

To simplify matters, we shall only consider the journeys and work of the train locomotives, steam and electric, in line traffic, and shall therefore ignore the work of shunting locomotives.

The different operations compared should be characterised technically by the following features:

	Electric operation according to statistics. Train locomotives and rail motor cars.	*Hypothetical steam operation.* Train locomotives.
1. Millions of gross ton-kilometres	9 400	9 400
2. Train-kilometres of the motor vehicles	27 976 200	28 176 200
3. Average weight hauled of the trains (1 : 2) in tons	336.0	333.6
4. Kilometres of the motor vehicles in service	30 718 990	32 125 840
5. Auxiliary kilometres of the motor vehicles (4-2) (Doube heading, running light)	2 742 790	3 949 640
6. 5 as a percentage of 2	9.804	14.018
7. Kilometres of motor vehicles in shunting service	245 000	245 000
8. Kilometres of motor vehicles (4 + 7)	30 963 990	32 370 840
9. Average annual number of motor vehicles	402.0	630.0
10. Gross ton-kilometres per motor vehicle	23 360 080	14 920 600
11. Kilometres per motor vehicle in line traffic	76 415	50 994
12. Total kilometres per motor vehicle	77 027	51 382

The values which we give merely by way of example are those which were utilised in a comparative study made by the Swiss Federal Railways between electric operation of 1929 and hypothetical steam operation. The values under numbers 3, 6, 10, 11 and 12 have been evaluated, on the basis of the statistics for 1928. They were exceeded in 1929 except the values under number 6. Of the values relating to steam operation, the number of locomotives in particular is quite fundamental. This number determines the hypothetical stock of steam locomotives which would probably have resulted from an old stock (of 1913 for instance) owing to old locomotives being discarded, the improvement of others still capable of being used and the acquisition of new locomotives satisfying the requirements of the increase in weight and speed of the trains, which increases were manifest from the start.

It should also not be forgotten at this place that the hypothetical stock of steam locomotives in developing naturally would not be an ideal stock. The average work done by the steam locomotives of the comparative hypothetical stock will be greater than that of the entire stock which would be necessary for the steam operation of the entire railway, because the electrified section of the railway comprises the lines on which the power of the locomotives is stressed more considerably. It is not possible to enter at this place more closely into the consideration of the method of determining the number of steam locomotives to be compared with the electric rail motor vehicles, or the average power of these locomotives or the other factors depending upon them. It will merely be pointed out that this determination ought to be a combination of careful calculations and conscientious estimations.

Considering that it is a matter of comparing an existing electric undertaking, the capital invested for electrification follows exactly from the accounts. We shall exclude the portion which may or may not relate to the equipment of the railway for the production and transmission of energy to the point of supply and will thus assume that the administration receives the energy for traction at the input side of its own substations. The capital for electrification and that which would probably have been necessary if steam traction had been retained are made up approximately as follows:

	Electric operation according to accounts.	*Hypothetical steam operation.*
1. Substations	......	———
2. Overhead contact lines, distribution stations, electric connections of rails, and protection equipment	......	———
3. Conversion of existing works (arrangement of the free space profile)	......	———
4. Conversion of electric installations. . . .	......	———
5. Repair shops	......	......
6. Depots	......	......
7. Rolling stock :		
a) Locomotives and rail motor cars . .	......	......
b) Electric heating of coaches	......	———
c) Steam heating wagons	......	———
Total. . .	......	......

We have not taken into consideration here the large incontestable economies which may be effected, with electrification, in the enlargement or reconstruction of stations and in the duplication of track. Electrification can scarcely involve the strengthening of bridges or new constructions which would not have been necessary had steam traction been retained. In regard to item 4, the degree to which the converted installations of the railway will bring economies in their respective operation, or the extent to which the conversions would have been necessary had steam traction been retained, ought to be taken into consideration. Under item 7a, it is necessary to include all the new steam locomotives which would have been acquired without electrification.

The sums appearing in the above statement should bear interest and be repaid. In addition, special depreciation payments or payments to a renewal fund should be calculated for smaller or greater portions of the installations mentioned under figures 1, 2, 5, 6, and 7 *a* to *c*.

Installations, the value of which is diminished or even reduced to nothing as a result of electrification, as for example, steam locomotives prematurely discarded, and some installations for the water and coal supply of locomotives which are no longer required, should not be a charge to the electrification capital but ought rather to be repaid on the account of electric operation, in proportion to their value which is not covered by the corresponding payments to the renewal fund.

It is advisable to divide and calculate separately for oneself the cost of electric energy taken from the contact line and the total cost of electric operation, as well as the cost of coal carriage free to depot and the total cost of steam operation.

The cost of the energy taken from the contact line is given by a calculation of the following type:

1. Cost of energy at the input side of the substations . .	. . . .
2. Cost of staff	. . . .
3. Cost of maintenance materials, repair materials and spares	. . . .
4. General and miscellaneous expenses	. . . .
5. Interest on capital	. . . .
6. Amortization of capital . . .	. . . .
7. Payments to renewal fund . .	. . . .
8. Depreciation of the value of the plant discarded on account of electrification .	. . . .
9. Allowance for the various internal receipts (arising from the utilisation of traction current for other uses of the railway, staff use, etc.)	. . . .
Cost of energy taken at the contact line	. . . .

We assume that the operation of the substations and the maintenance of the contact lines are combined in one organisation as on the Swiss Federal Railways.

The cost of power at the input of the substations is the total sum charged by the supplier of energy.

The cost of the staff includes pay, allowances, service clothes, emoluments, accident insurance, and contributions of the administration to the pension and sick fund or to similar institutions.

The general and miscellaneous expenses may contain a just portion of the cost of the general administration.

The interest on capital for installation, items 1 to 4 of the scheme on page 506 ought to be included in this calculation. The rate of interest should correspond to the rate for the capital borrowed immediately before and during electrification. It comprises the repayment of the expenses of issuing the shares and the quotation losses. The use of an arbitrary rate

is not admissible in view of the important part played by the interest charges in the comparison.

The usual amortization of the capital does not require any remarks.

The payments to the renewal fund are often the subject of different conceptions. Their purpose is to render it possible to discard, within certain intervals of time and without accountancy losses, certain portions of the plant which, owing to natural wear to its becoming old in regular service but not owing to rough use, may on the whole become useless in these intervals of time. All those administrations who have a renewal fund, do not make the payments to it in the same manner. The Swiss Federal Railways, in 1929, paid more than 9 500 000 francs into the renewal fund allocated exclusively to their electrified lines, that is to say, about 11 % of the cost of electric operation, including that of the power stations. The payment to the renewal fund allocated to the corresponding hypothetical steam operation would only amount to about 2 200 000 francs or to about 3.2 % of the cost of steam operation. We should like to take this opportunity of drawing attention to the importance assumed by the payments to the renewal fund in the comparison between the two types of operation. Consequently, these payments should be taken into consideration not only in a general manner but also exactly. The special payments for the depreciation of locomotives and mechanical and electric plant as they become old is without doubt necessary. Compared with steam operation, electric operation has, in the substations and contact lines, such a surplus of plant, the depreciation of which has to be allowed for specially that excessively large or excessively small payments to the renewal fund would falsify the comparative calculation.

One could dwell at length on the theory and practice of payments to the renewal fund and its utilisation. The practice of the renewal fund becomes all the more what may be called life insurance, the more severe the condtions under which contributions are made from the fund, that is to say, as the extensive repairs, improvements and replacements count less as renewals, and the life of the insured objects increases. The Swiss Federal Railways pay to the renewal fund 3 % of the purchase value for mechanical and electrical plant. The accumulation of the payments without interest attains in 33 years the amount of the insured capital. On the contrary, the covering capital is collected even after 22 years if the compound interest at 4 % is included. If, under these conditions, the capital has only to be attained after 33 years, the rate of the payments may be reduced from 3 % to about 1.5 %. Leaving open the question as to whether the period of 33 years is suitable, we share the opinion that payments to the renewal fund ought to be calculated on the basis of mathematical insurance, if it is a question of an economic examination. It would be desirable for the representatives of the administrations to come to an agreement regarding:

1. the renewal periods for different kinds of objects, namely mechanical and electrical plant, contact lines, transmission lines, electric and steam locomotives, etc.;

2. regarding the acceptance of the renewal, and

3. regarding the rate of the payments, this of course without involving any liability for the accountancy departments of their administrations, but solely for the purpose of conducting economic investigations and above all for the purpose of making a comparison between electric and steam operation.

It will be necessary to add to the internal receipts included in the accounts any sums levied on the renewal fund.

The determination of the cost of coal in the comparative steam operation in-

volves the previous determination of the consumption of coal. In our hypothesis, the stock of locomotives of the comparative steam operation comprises old locomotives, improved or otherwise, and new modern engines. The coal consumption per gross ton-kilometre differs from the previous coal consumption on the entire railway operated by steam and from present consumption on that section of the railway which is still steam operated. It will be influenced by the assumed extent to which the hypothetical steam operation ought to approach the electric operation in regard to the travelling and average speeds, hence also in regard to the accelerations. The coal consumption per gross ton-kilometre increases rapidly when the locomotives are forced beyond a certain limit. The increase in the speed of trains is demanded so insistently by the clients of the railway, particularly when electrification comes into consideration, that the administration is obliged to accede to it as far as possible. It must therefore be assumed that all that the locomotives of the hypothetical steam operation could provide would be obtained from them, even to the detriment of a better coal consumption. The steam operation of a very hilly railway which, to a certain extent, is intended to equal electric operation would have at all events a relatively high coal consumption per gross ton-kilometre. This degree of equality, as also the hypothetical coal consumption, are difficult to determine. We shall have to be content if an estimate is found to be too low by one expert and too high by another.

It is necessary to deduct from the hypothetical coal consumption, determined or real:

a) the coal consumption of the heating wagons;

b) the coal consumption for steam locomotive journeys caused by electric operation.

In this way, we obtain the quantity of coal saved by the electric operation, the cost of which should be calculated approximately as follows:

1. Cost of the coal taken at the pit or delivered carriage free to the nearest station of the railway in question and possibly cleared by customs;

2. Cost of transport of the coal on this railway from the place of delivery to the depots;

3. Hire of wagons.

The calculation of the cost of transport on the lines of the administration in question should not be made on the basis of a conventional service tariff. We know that the question as to what a service transport costs is a matter of some dispute. In this case, it would appear advisable to deduct from the operating account the actual transport charges per gross ton-kilometre of the total traffic, that is to say, the charges which depend exclusively upon the locomotive-kilometres, the axle-kilometres, the gross ton-kilometres, etc. The general and fixed charges would be excluded as far as possible, so that it would be possible to say that the transport of a ton-kilometre effectively costs at least the price thus obtained.

The calculation of the cost of the coal could, strictly speaking, be completed to the advantage of steam operation by the following deductions:

a) cost of the supplementary consumption of coal or coke for heating locomotive sheds, resulting exclusively from electric operation;

b) receipts from the sale of combustion residues (clinker).

These two items are of secondary importance, the second moreover being very variable.

After these preliminaries, the comparative calculation may be developed approximately according to the following scheme :

	Electric operation.	Hypothetical steam operation.
1. Cost of energy taken at the contact line . .	......	———
2. Cost of coal, carriage free to depot . . .	———	......
3. Cost of locomotive staff	......	......
4. Cost of maintenance of motor vehicles . .	......	......
5. Cost of lubrication of motor vehicles . . .	......	......
6. Value of the materials not utilised or less utilised in electric operation (kindling materials, water, sand, paraffin, etc.) . .	———	......
7. Depot staff economised by electric traction for coaling and cleaning locomotives (unloading coal, loading tenders, transport of clinker and ashes, cleaning locomotives)	———	......
8. Permanent way staff economised by electric traction for maintenance of the track in tunnels	———	......
9. Train staff economised by electric traction.	———	......
10. Total cost of the heating wagons . . .	......	———
11. Cost of maintenance of the heating of trains	?	?
12. Interest on capital	......	......
13. Amortization of capital	......	......
14. Payments to the renewal fund	......	......
15. Depreciation for the values destroyed owing to electrificfation	......	———
Total . . .	......	......

The cost of the locomotive staff includes pay, allowances, bonuses, service clothing, fees, accident insurance and contributions of the administration to the pension and sick fund or to some other similar institution. The number of drivers and assistant drivers of the electric locomotives and that of the drivers and firemen of the steam locomotives should be noted carefully because occasionally the staff of the electric and steam locomotives in a large electrified system operated by the side of a large steam operated line is not separate and statistics regarding this will therefore be lacking. The totals under item 3 differ considerably from one another on account of the considerable difference between the number of electric locomotives and that of steam locomotives. This difference becomes still greater when a large part of the electric vehicles are driven by one man, or by one qualified man assisted by a train employee.

The cost of the maintenance of the motor vehicles ought to include the general charges of the repair shops, which should be regarded as establishments meeting their own needs and possessing their own accounts. The cost of the maintenance of the electric vehicles may in our hypothesis be drawn from statistics. As regards the cost of the maintenance of the steam locomotives of the hypothetical undertaking, it would be necessary to proceed in a manner similar to that for

coal. We are concerned here with steam locomotives, of which only their highest averages in driving axles, axle load, steam pressure and steam temperature are known with certainty, in regard to the locomotives in service on the railway of the same administration before electrification, or which are still in service on the non-electrified section of the railway. A special investigation on this subject would most certainly give certain and appreciable indications if the existing steam undertaking is still considerable and if it comprises lines on which new and powerful locomotives are employed. The operation of the Swiss Federal Railways ceased to provide this possibility even before 1928.

It should not be forgotten either that absolutely reliable elements of calculation can only be given by mean values covering about 3 years at least and relating to a sufficiently large locomotive stock, constitued naturally but not arbitrarily and still less with a bias. The maintenance cost of the stock of steam locomotives runs the risk of being underestimated, because the locomotive-kilometre is only a relative unit and only favourable under certain conditions. The maintenance charges of locomotives of the same type of construction and of the same employ, per kilometre travelled, increase in proportion to their size, but they may, on the contrary, diminish considerably with respect to the work performed in gross ton-kilometres. We do not, however, mean to say by that, that the ton-kilometre would be in general preferable to the locomotive-kilometre as relative unit for defining the maintenance cost of the locomotives. The items under numbers 6 to 9, economised by electric traction, are considered in the scheme as component of the cost of steam operation. The maintenance costs of the track in tunnels is undoubtedly reduced by electric traction. A substantial reduction of these charges outside the tunnels could hardly be expected as a general rule. The preservation of the track and bridges resulting from a better distribution of the masses on electric locomotives ought to be off-set by the effect of the greater speeds and axle-loads which as a rule are somewhat higher.

The saving in train staff depends upon many circumstances. A close examination of the question shows that this economy remains below what is generally expected. The inspection of tickets in passenger trains, on very frequent electric trains making many stops, may require an extra employee owing to the time of run between stations being shorter than that of steam trains of the same frequency.

The operating cost of heating wagons should of course be debited to the electric undertaking. It should be determined on the basis of a special investigation. These heating wagons are still necessary even in Switzerland, on account of the foreign coaches which run in international trains and which can only be heated by steam. The expenses should be determined.

The maintenance costs of electric heating for the coaches and those of the steam heating not utilised are trifling but are not known for each of them. It is not impossible that together they may be greater than the maintenance costs of steam heating alone.

The statements relating to the scheme on page 868 apply by analogy to figures 12 to 14 of the above scheme. It should be pointed out that only the capital invested in the new steam locomotives of the hypothetical stock is subject to depreciation and should bear interest. The interest and depreciation of the capital represented by the old locomotives cannot be economised by electric traction.

The payments to the renewal fund should of course be reckoned for all the locomotives of the hypothetical stock.

If values are destroyed on account of electrification, it is necessary to distinguish those for which the renewal fund

contains a partial off-set value and those for which this off-set value does not exist. The first of these values will probably only concern prematurely discarded steam locomotives. The repayment of the values discovered should not in any case be a charge on the working account for a single year, but should be distributed over several years according to a reasonable depreciation plan, taking into account payments already effected for ordinary and special depreciations. These depreciations will not considerably affect the comparative calculation even if many locomotives have to be discarded, as was the case on the Swiss Federal Railways.

When electrification only leaves a small steam-operated section of the railway of the administration in question (only about 15 % gross ton-kilometres on the Swiss Federal Railways), it is necessary to see whether the existing steam operation has not been rendered more expensive on account of its reduction and its dismemberment, as compared with the same steam operation as an integral part of the steam operation of the entire railway. This increase in cost may be due, *inter alia*, to an insufficient utilisation of the capacity of the locomotives retained in the existing operation on account of the greater part of the older and weaker locomotives being discarded, such that their coal consumption per gross ton-kilometre is a little greater. It cannot be considerable and can only be estimated very approximately.

Finally, a recapitulation according to the following scheme may be of interest.

—	Electric operation.		Hypothetical steam operation.		Difference in favour of electric operation.
	Amount.	Percentage of total.	Amount.	Percentage of total.	
	Francs.		Francs.		Francs.
Cost of staff and stores	23 762 000	35.1	66 168 000	91	42 496 000
Amortization of capital and payments to renewal fund	9 375 000	13.9	2 480 000	3.4	— 6 896 000
Interest on capital	34 537 000	51.0	4 086 000	5.6	— 30 452 000
	67 674 000	100.0	72 734 000	100.0	5 058 000

By way of example, we give the figures resulting from the comparison previously mentioned between an instance of electric operation in 1929 comprising a traffic of 9.4 billions of gross ton-kilometres on 1 679 km. of line, 2 619 km. of main tracks and 402 train locomotives and rail motor cars, and the corresponding hypothetical steam operation. It should be noted that in this example about 1/3 of the capital is invested in the power stations and transmission lines. This recapitulation shows, what is moreover certainly common knowledge, that the most important items of the cost of operation are, for electric operation, those depending upon the capital involved and, for steam operation, those independent thereof. This means that the economy effected by electric operation reacts more to the fluctuations of traffic and receipts than steam operation.

We shall close this chapter with the following remarks.

Statistics and the usual schemes of accounts cannot be utilised to the desired

extent for the arithmetical treatment of the comparison between the two kinds of operation. It does not appear to be possible to adapt them to the particular requirements of such comparison. The constitution of the comparative hypothetical steam operation is not easy and is not to be trusted. The risks of favouring the hypothetical steam operation rather than the electric operation are great. This opinion, which is ours, is based on the statements of superior and subordinate officials who have been engaged for years in electric operation and to some extent are still engaged in steam operation, and who, previously, were engaged in steam operation alone. The arithmetical comparison is only capable of emphasising other very important material possibilities inherent to electric traction, while it assumes a steam operation with notoriously very hypothetical possibilities of a greater development.

It would only be possible to judge exactly of the economic prospects of new extensive electrification on the basis of numerous arithmetical comparisons made conscientiously. Each comparison should, however, be accompanied by a description of the electric and steam operations in regard to everything of importance, including the exceptional circumstances in which electrification was carried out, so as to render comprehensible the differences between the information given by different administrations under the same designation and to avoid wrong comparisons between the undertakings of different administrations.

Finally, it might be thought that it would not be necessary to draw up such a complete scheme of comparison and that certain items of lesser importance may be ignored. In this connection, we would point out that the economic question is all the more critical, the greater the electrification considered and that consequently it is necesary to take into consideration all the tangible factors which may affect it.

VI. — The replies of the administrations.

We should first of all like to tender our thanks to the administrations who have replied as far as possible to the numerous questions, some of which may have required no small amount of investigation.

In reply to the fundamental question as to whether the railways of any one administration comprised a section operated by steam, sufficiently similar from all the essential points of view to the electrified section to permit a strict technical and economical comparison between the two types of operation, on the basis of experience gained simultaneously, all the administrations answered « no », with the exception of the German State Railway Company which is in a position to make, and is making, comparative calculations on the basis of working reports made expressly for the purpose.

A number of questions were left unanswered or were understood in different ways. The replies which enable interesting conclusions to be drawn from them are recapitulated in table IV.

It will be seen in this table that the urban and suburban railways of Hamburg and Berlin possess a volume of traffic, expressed in both train-kilometres and ton-kilometres, which is very much greater than that of all the other electrified railways. This peculiarity is by no means extraordinary. It follows from the character of these railways, to the electrification of which everything pointed, from both the point of view of the traffic and the point of view of the type of their operation.

Ordinary electrified railways have a volume of trafic of 4 000 to 8 500 gross ton-kilometres per kilometre.

Those having a lower specific volume of traffic, such as the Wiesental Railway, the Bernese Alps Railways and the Rhætic Railways have been electrified principally on account of steep gradients.

The use of either locomotives or rail motor cars for hauling trains depends

considerably upon the character of the line and of the traffic. Thus, the rail motor car is found mostly on level lines or sections of line with heavy and light traffic, while the locomotive retains its first place on lines having steep gradients. Urban and suburban railways employ exclusively rail motor cars in a relatively large number, due to the fact that each train is generally composed of several motor cars. On other railways with a distinct local service, the proportion of motor vehicles varies between 4 to 7 locomotives to one motor car.

The average annual mileage of motor vehicles (locomotives and cars) depends principally upon the type of traffic to which they are allotted, the character of the railway and speeds. Despite a high degree of use, the mileage of goods train locomotives must be the smallest on account of the reduced speed of this class of train and the prolonged stops. The average length of run of passenger train locomotives is affected considerably by that of the locomotives of this class assigned to the mixed working of passengers and goods trains. No administration has been able to give the mileages run by each of these categories of locomotives, owing to the indiscriminate use of the engines. The average annual mileage of the two categories together varies between 21 125 and 52 825 (34 000 and 85 000 km.) per locomotive. The longest average mileage of certain locomotives exceeds considerably the corresponding average of all the locomotives. Thus, on the Swiss Federal Railways, the 37 passengers train locomotives of class A^e 4/7 give the annual average of 144 177 km. (89 590 miles) per locomotive and the eighteen class C^e 6/8 locomotives assigned to the through goods train service give an average annual run of 104 235 km. (64 770 miles) per locomotive. On the Rhætic Railways, the most powerful locomotives run annually an average of 76 699 km. (47 660 miles) as compared with the average of 64 161 km. (39 870 miles for all the electric locomotives. The rail motor cars working exclusively on urban lines with heavy traffic run an average of up to 103 400 km. (64 500 miles); on lines with less traffic where they take the place of small locomotives, the distance run barely exceeds the average for all the motor vehicles.

The average gross ton-kilometres hauled per locomotive, shown in table IV have been calculated on the basis of the data provided by the administrations. The investigation made by the Swiss Federal Railways has shown that the average work done by the electric locomotives is 23.83 millions of ton-km. (14.56 millions of Engl. ton miles), while that of the steam locomotives in the corresponding hypothetical operation is only 14.9 millions (9.1 millions of Engl. ton-miles).

The effective availability of the motor vehicles is the time during which they are in service or available for service. It is expressed as a percentage of the whole year and already is as high as 93 %. As long as the working conditions are normal, the coefficient of availability may be said to lie within the limits of 0.75 to 0.93. According to the administrations who have replied to the question, the coefficient of availability of the steam locomotives under similar operations would be between 0.60 to 0.73.

The quotient obtained by dividing the kilometres travelled by the motor vehicles, by the train-kilometres (number 18 in the table) gives the average number of motor vehicles per train and shows principally the extent to which double traction is in use on the various railways. These factors cannot be compared with one another without taking into consideration the working conditions of each line. Thus it is quite regular that double traction on railways operating with rail motor cars, in which a motor car with its set of coaches is added or removed in order to vary the composition of the trains, should be in a greater proportion than on railways operated with locomo-

tives alone. On the latter, double traction is only resorted to as a rule for hauling exceptionally heavy trains or to reinforce the regular locomotives on steep gradients. Double traction is particularly insignificant on the railway operated by the Berne-Loetschberg-Simplon Company (1.08 locomotives per train), because its own line, with long steep gradients, constitutes an independent undertaking for which this company possesses 4 000-H. P. units capable of hauling the heaviest trains over the whole line. The Swiss Federal Railways come second for the minimum of double traction and « light » trips, with 1.2 locomotives and motor cars per train. The double traction and « light » trips are in the proportion of about 1 to 1, so that double traction alone only constitutes about 6 % of the runs of the motor vehicles. This coefficient will diminish a little owing to two new locomotives, each of about 8 000 H. P., being put into service for single traction of heavy trains of the St. Gothard line.

The characteristics of the most powerful locomotives reveal one of the objects of the electrification of some lines. The construction of powerful units results not only from the increase in weight of the trains and the inconveniences of double traction, but also from the increase in speed on heavy gradients, a speed which is reduced considerably for all classes of steam trains.

One-man operation of locomotives has been introduced on a fairly large scale. In Germany the question has been settled for the moment by the train conductor taking the place of the assistant driver on the electric locomotive of all trains the speed of which does not exceed 75 km. (46.5 miles) per hour. In Czechoslovakia the assistant driver is replaced by the train conductor on all locomotives. In Switzerland, the Federal Railways have 220 locomotives out of 377, and all their 55 rail motor cars adapted for oneman driving. The Bernese Alps Railway Company has 18 locomotives out of 33 and all its 11 rail motor cars, and the Rhætic Railways, their 30 locomotives, driven by oneman. Electric locomotives are still driven by two men in Austria when in traffic; the number is however reduced to 3 men in all for double traction trains. All the electric locomotives, however, are fitted with the safety device for oneman driving.

Locomotives with regular drivers are generally assigned to 2 drivers who may be supplemented by a third when the turn of service of the former is not sufficient to cover the day's work of a locomotive. This system has been introduced particularly on the German State Railway Company's lines, other than the Berlin and Hamburg urban and suburban railways. On the other railways, the locomotives are more or less completely pooled. In some places, they are pooled as regards the staff of the depot to which the locomotives are attached, while in others the pooling of the locomotives is carried much further. Where there is such pooling, it applies indifferently to both locomotives and rail motor cars.

As regards the staff of the locomotives, Mr. H. Mühl, of Munich, in his article entitled « The Fourth Year of Operation of the Electrified Bavarian Railway » gives the proportion of 0.55 for the staff of electric locomotives relatively to that of steam locomotives.

The specific power consumption, expressed in watt-hours per gross ton-kilometre hauled, and measured at the central power station or the place of supply, varies within very wide limits between 23 and 110 w.-h. per gross tkm. (177 w.-h. per Engl. ton-mile). It is thus an individual factor for each railway. The smallest consumption of 23 w.-h. per gross tkm. (37.5 w.-h. per Engl. ton-mile) approaches very closely the theoretical consumption for traction exclusively on a railway in flat country where the trains are heavy and the tare weight of the locomotives is relatively small, where the dis-

tances between stations are fairly large and where steam heating of trains is retained. It rises to 32 w.-h. per tkm. (52 w.-h. per Engl. ton-mile) for a similar operation of a railway with steep gradients. The energy is provided within the area of the railway and is utilised without preliminary transformation. When operating a ring and suburban railway, the specific consumption is 53.5 to 55 w.-h. per tkm. (86.5 to 88.5 w.-h. per Engl. ton-mile). It is fairly high chiefly on account of the short distances between stations and the many starts. The complete electric operation of a non-uniform system of varying characteristics comprising lines through level country and lines with steep gradients, such as the electrified system of the Swiss Federal Railways, has an average specific consumption of 47 to 48 w.-h. per tkm. (76 to 78 w.-h. per Engl. ton-mile) including the power consumption for shunting in large stations, as well as for electrically heating the trains, with the exception of some international expresses. The excessive specific consumption of 110 w.-h. per tkm. results from a superannuated supply system by means of convertors and buffer-battery of accumulators.

VII. — Type of supply of electric power.

The power supply to a railway is no longer a railway problem in the proper sense of the word, but comes within the scope of electrical engineering.

Power production, that is to say, the operation of electric power stations, cannot therefore, commercially speaking, be confused with the actual operation of the railway. Power stations belonging to and operated by the railway itself ought, properly speaking, to be regarded as a special or accessory undertaking and be dealt with in special accounts. These accounts should be drawn up like those of a private undertaking, taking into consideration the special circumstances relating to the service of the capital, amortization and renewal of plant. Whoever owns the power stations, therefore, it is the business of the railway undertaking to determine its power requirements and to make them known early enough so that the proper steps may be taken to satisfy them. The electric power stations undertake to produce this energy with the required certainty, and supply it to the railway under agreed conditions at agreed prices. These supply conditions of course comprise the operating costs of the electric power stations and of the lines for the transport of energy to the place of supply. The production of energy thus reduces itself, as regards the actual railway operation, to concluding energy supply contracts with its own power stations (fictitious contracts) or with private power stations and undertakings.

The price of thermo-electric energy, produced close to the mine with lignites, varies in Germany between 2.57 and 3.2 Reichspfennig (Rpf.) per kw.-h., taken at the power station. This price rises to 5.8 Rpf. per kw.-h. when the energy is produced in steam-operated power stations using good quality coal obtained from a distance. In Bavaria, hydro-electric energy is bought from private power stations at the rate of 2.62 Rpf. per kw.-k. taken at the power station. The energy produced in the hydro-electric stations of the Swiss Federal Railways comes to 2.54 centimes per kw.-h. taken at the power station, to 3.85 centimes per kw.-h. at the input to the substations and to 4.77 centimes per kw.-h. at the point of supply to the contact line. The energy bought costs 5.92 centimes per kw.-h. delivered at the point of supply to the contact line. The Bernese Alps Railway pays for energy at the rate of 3.4 centimes per kw.-h. taken at the power station and, for some of its lines, up to 7.5 centimes per kw.-h. according to the place of delivery. The Rhætic Railways buy single-phase energy, at the working voltage, at the

rate of 7.1 centimes per kw.-h. delivered to the point of supply to the contact line. These prices give some idea of the cost of energy. They can only be compared together on the basis of supplementary information into which we cannot go here as it would take us too far from our subject.

The type of supply of energy to the railway is necessarily that which corresponds to the most economical solution. It depends upon the means and possibilities of producing the energy, as well as the availability, transmission facilities and other circumstances.

A railway which is not able to take part in the electrical industry can also only own profitably one or more power stations for supplying its energy if its own requirements and its conditions of consumption permit such stations to be utilised rationally, and if the railway finds an interest itself in profiting by the pecuniary gain which any well conducted undertaking, hence also electric power stations, ought to produce. The condition for the rational utilisation of railway power stations can certainly be satisfied if the annual requirements of energy exceed 100 millions of kilowatt-hours. Thus the German State Railway Company possesses in the Central Region and in Silesia its own steam power stations capable of furnishing respectively 90 and 210 millions of kw.-h. The Austrian Federal Railways operate 4 hydro-electric power stations of a total capacity of 125 to 150 millions of kw.-h. according to the hydrographical conditions. The Swiss Federal Railways, in order to meet the bulk of their energy requirements, possess 4 large and 2 small hydro-electric stations furnishing together 457 millions of kw.-h. In their turn, such power consumptions imply railway systems of several hundreds of kilometres in length, which have to be supplied with energy at several points, even if the working voltage of the railway is one of the highest used up to the present time. The distribution of the energy for locomotion necessitates at these places, in addition to the overhead contact line, electric lines called transmission lines, operated at voltages which are much higher than those of the contact line. Due to this fact, the construction of power stations for the railway's own requirements is favoured in regions where, owing to the absence, or insufficiency, of an industrial electric supply network, it is necessary to establish private distribution lines. This construction is handicapped, on the contrary, when an existing or projected industrial supply network has a capacity of transmission which is sufficient for supplying the railway with the complete reliability required.

In several cases in which the railway could not alone operate a whole power station rationally, it has secured for itself the economic advantage of producing its energy in association with a private electric undertaking, as regards the construction and operation of a joint power station.

Since it is impossible to transmit over a long distance the continuous current required for the operation of a railway, such current can only be obtained by transforming industrial currents, preferably three-phase currents at 40 to 60 cycles. Thus, continuous-current railways find there is no advantage in possessing their own power stations and readilly give up the idea of building them, even when their power needs are great.

The production of single-phase current by transforming three-phase current is not generally advantageous and sacrifices the simplicity of single-phase current distribution. For this reason, railways utilising single-phase current are tempted to produce their energy in their own power stations. There are many cases, however, in which industrial power stations produce single-phase current in addition to their principal production, or supply single-phase current obtained by transforming industrial current.

Attempts have been made to use industrial current directly for traction, in Italy with three-phase current at 45 cycles, and in Hungary with single-phase current at 50 cycles taken on one or other of the phases of the three-phase mains and transformed on the locomotive into three-phase current.

The position of the power stations is determined by the natural sources of active or latent energy. Thus, the utilisation of water power, lignites, and blast furnace gas implies the production of electric energy at the very places where these sources are to be found.

For operating the railway, as everywhere else, it is only possible to select from among the various available and utilisable sources those which are most suitable, not only on account of the fact that their geographical situation is more or less favourable with respect to the railway, but also from the technical and economic point of view. The electrical transmission of energy being always less expensive than the transport by rail of the equivalent quantity of any fuel coming into consideration, it may be assumed that thermo-electric power stations will only be established at any other place in exceptional cases when navigation facilitates the transport of fuel and when it is a matter of creating a reserve source to meet an accidental or occasional lack of power.

The substations where the energy is transformed to the working voltage of the railway, and distributed in the contact lines of the corresponding section, as well as the contact lines and accessories come within the scope of the actual operation of the railway. Their distribution along the railway or along the system depends in the first place upon the admissible drop in voltage compatible with regularity of working and economy in general. Starting from this fundamental principle, the substations are situated for preference and as often as possible, at the railway junctions which are the distribution centres for all the lines meeting there. On railways operated with continuous current at 800 volts, the distance between the supply points scarcely exceeds 8 km. (5 miles). The intervals attain 20 km. (12.4 miles) on railways in flat country and 10 km. (6.2 miles) on railways with steep gradients, operated with continuous current at 1 500 volts. As regards railways operated with single-phase current at 11 000 to 15 000 volts, the average distance between the substations varies between 50 and 80 km. (31 and 50 miles) according to the character of the line.

VIII. — Choice of the kind of current.

The characteristic features of the fundamental systems of electrification are the type of transmission of the current to the motor vehicles, etc., and the kind of the current. As types of transmission of the current, in principle only the third conductor rail and the overhead contact line are used, irrespective of the type of construction of the installations.

According to Publication No. 079 of the *National Electric Light Association*, previously referred to in Chapter II, the different systems employed were distributed at the end of 1929 among the electrified railways of the whole world as follows, special cases, including the Chambéry-Modane electrification with 1 500-volt continuous current and third rail, being omitted :

1. *Electrification with 3rd and 3rd plus 4th contact rail and with continuous current at a working pressure of less than 1 000 volts*, about 1 900 km. (1 180 miles) of line, or 15 %, — or 5 100 km. (3 170 miles) of track or 19 %.

2. *Electrification with overhead contact wire :*

a) *Continuous current at :*

1) 1 200 to 1 500 volts, about 3 600 km. (2 237 miles) of line, or 29 %, — or 8 000 km. (4 971 miles) of track, or 29 %;

2) 2 000 to 4 000 volts, about 2 700 km.

(1 678 miles) of line, or 22 %, — or 4 000 km. (2 485 miles) of track, or 14 %.

b) *Three-phase current at:*

3 000 to 3 700 volts, about 1 330 km. (826 miles) of line or 11 %, — or 2 800 km. (1 740 miles) of track or 10 %;

c) *Single-phase current, 25 cycles,* 10 000 to 15 000 volts, about 1 130 km. (702 miles) of line or 9 %, — or 2 800 km. (1 740 miles) of track, or 10 %;

d) *Single-phase current, 15 to 16 2/3 cycles, at* 11 000 to 15 000 volts, about 3 600 km. (2 237 miles) of line or 29 %, — or 9 800 km. (6 090 miles) of track, or 35 %;

Total about 12 400 km. (7 700 miles) of line, or 100 %, — 27 500 km. (17 090 miles) of track, or 100 %.

Electrification effected in 1930 and actually in course of construction, as well as that decided upon, will appreciably increase the extent of each system, but particularly the extent of the D. C. 1 500-volt system and the system using single-phase current at 15 to 16 2/3 cycles, and at 25 cycles. (Electrification of the Pennsylvania Railroad).

The working voltages most employed and accepted as standard in certain countries are, for the systems enumerated hereafter:

1 — 600 to 650 volts generally;

2*a* 1 — 1 500 volts, standard in France, England, Holland, Czechoslovakia, and adopted on a large scale in Spain, the East Indies, Japan and Java;

2*a* 2 — 3 000 volts, adopted in Southern Italy, United States, Brazil, Chile, Mexico, Morocco, South Africa;

2 *b* — 3 700 volts, 16 2/3 cycles, adopted only in Italy, north of Rome, but on a large scale and as standard;

2 *c* — 11 000 volts, 25 cycles, voltage and frequency adopted on a large scale only in the United States;

2 *d* — 15 000 volts, 16 2/3 cycles, voltage and frequency adopted as standards in Norway, Sweden, Germany, Austria, Switzerland.

The lengths of the lines and tracks electrified according to the different systems mentioned in the foregoing show that each of these systems has found extensive application, which would be incomprehensible if it had not been found satisfactory long ago, at least in the important and determining cases, from both the technical and economic points of view.

The important instances of electrification under number 1 concern almost exclusively lines having heavy passenger traffic, situated in large towns and branching out into the suburbs. Although low tension and 3rd rail have a historical reason in such instances of electrification, yet both are constantly being found to be the best solution of the problem which arises in such instances of electrification. Whereas 3rd rail with a working tension of 1 500 volts is being used successfully on the Chambéry-Modane line by the Paris-Lyons-Mediterranean Railway, electrification with 3rd rail and a working voltage lower than 1 000 has not, for economic reasons, been capable of extension beyond the zone of the intense suburban traffic. The 3rd rail system at a voltage of less than 1 000 does not therefore enter the question as far as extensive electrification, including long lines, is concerned. For extensive urban and suburban electrification, this system has such advantages that it has been adopted for such places even when, as in the case of Berlin, the single-phase system at 15 000 volts, 16 2/3 cycles, is the standard. The Berlin electric undertaking, both in traffic and power consumed, exceeds by far the large electric undertaking in Bavaria and thus justifies the choice of a system expressly for the purpose. In this case, the solution shows itself well thought out by the fact that the 3rd rail does not increase the difficulties of erecting in the Berlin stations, the overhead contact wire used on the main lines, even over the tracks provided with 3rd rail. The latter works in with

all types of contact lines, irrespective of the nature and voltage of the current.

The instances of electrification under number 2 *b* appear to be confined to the extensive northern portion of Italy in view of the fact that the lay-out of the railway and the possible supply of energy in the central and southern portions favour other systems. The technical and economic success obtained with three-phase electrification in northern Italy are none the less indisputable and this electrification will be extended still further. This system of electrification will be applied all the more in special cases in countries where electrification under number 2*a*, 1 and 2, 2*c* and 2*d* has covered a considerable area.

High-tension continuous current and single-phase current systems of electrification are thus the only ones employed on a larger scale which remain in competition for new instances of extensive electrification, provided the choice of the system is not already determined by official standards, it being understood also that, of the single-phase current systems, in north America only 2*c*, and in Europe only 2 *b*, do not come into consideration. We cannot, however, omit to mention that the electrification in central Italy, with three-phase current at 45 cycles and with bipolar contact line as well as the Hungarian electrification with three-phase current at 50 cycles and with unipolar contact line, both effected as a test with a view to the direct utilisation of industrial power, are of interest. Tensions higher than 3 000 volts for continuous current and 15 000 volts for single-phase current adopted in a few isolated cases will scarcely find wider application.

According to what has been said, the choice of the system is so limited as to lead one to believe that there is no room for considerations of an economic character. This would not be true, however, even where electrification has to be effected according to the standards in force. The system, in the meaning accepted at the beginning of this chapter, only fixes the nature and the tension of the current in the contact line. It does not determine either the type of transformation of the electric energy, supplied to the motor vehicles, into the mechanical work of traction nor the transformations which this energy has to undergo from its production in the power stations to its reaching the contact line. The first transformation does not meet with a great variety of different methods. The simplest means are known and, as a rule are the best from both the technical and economic points of view. The transformations required for the transmission of the energy, on the contrary, allow each system to be combined with each type of supply, either in regard to the nature and voltage of the current or in regard to the source of power. The existing instances of electrification provide examples of almost all the combinations imaginable. Considering the variety of the cases and the special circumstances, it is impossible to state in a general manner what is the most advantageous combination.

The economic importance of the choice of system could not be examined more closely without going beyond the scope of this report. This question would require special and extensive study. We shall confine ourselves to the following remarks:

Since installing on a large scale electric operation with rail motor cars using continuous current at 3 000 volts on the Lackawanna and Western Railroad, it is impossible to accuse any of the systems coming under consideration of not providing the key to all traction problems on a large railway undertaking.

When the system of electrification is dictated by standards, the arrangements concerning the supply of energy remain the subject of decisions which may still influence the economy of a new electric undertaking. If the continuous-current system has to be employed, the nature,

voltage and origin of the primary energy may be technically of any kind whatsoever. The acquisition of energy is an ordinary business affair with an electric power station, designated in most cases by the circumstances, unless the production of energy by the railway itself is indicated. If the single-phase current system has to be employed, the question arises as to whether its ideal simplicity, consisting of the use of primary single-phase energy, can be realised, or whether the transformation of industrial energy is more profitable. In the first case, the question is connected with that of the production of energy by the railway itself, and this question has been touched upon in the last chapter. The use of primary single-phase energy is not absolutely a condition for economical operation with monophase current. In cases like that of the Stockholm-Göteborg Railway (single track line 458 km. = [280 miles] long, heavy trains requiring considerable power), it is not only the single-phase system which is most clearly indicated, but also the supply of energy by the transformation of three-phase energy provided by existing electric power stations connected to a suitable distribution network.

In those cases where the choice of system is free, the following general opinion may be stated:

The points of supply, that is to say, the substations, should be the further apart, and the working tension in the contact line should be the higher, that is to say, the monophase system will be all the more indicated, the longer the line to be electrified, the greater the traction powers required for each train, the lower the frequency of the trains and the smaller and more irregular the volume of the traffic, this for technical and economic reasons. The continuous current system is technically and economically all the more indicated, the more the conditions differ from those mentioned above. The system with tensions of less than 1 000 volts enters more into consideration, the greater the importance of the urban and suburban traffic, as well as the rail motor car service, in the operation of the railway. The system with continuous current at 3 000 volts of course adapts itself better to unfavourable conditions than that of 1 500 volts, but nevertheless is not equal to the single-phase current system.

Such are the points of view from which it is possible to judge of the extent to which the system of electrification dictated by standards is suitable in a given case.

Considering the present level of perfection of the systems, and by reason of their forms of execution and adaptation, the choice of the system no longer possesses the importance it had formerly in regard to the technical and economic success of electrification.

The questionnaire included the question as to whether the Administrations would, at the present time, choose another kind of current than that adopted when they first electrified their lines.

The German State Railway Company, the Austrian Federal Railways and the three Swiss Administrations concerned plainly stated that their choice would remain unaltered; the Austrian Federal Railways however intimated that the single-phase 50-period system would also be considered if it had already given conclusive results.

IX. — Safety measures.

In the first place we take it that the question set aims principally at the safety of persons — staff of the railway and persons unconnected with the railway — and that its object is chiefly to reveal the safety measures peculiar to electric traction rather than those concerning the use of electricity in general. We thus assume that the elementary precautions, which are the rule in every electric installation, are known and we shall not recall them. As to the remaining safety measures, they

would be important enough to form a special report by themselves, if this question had to be dealt with thoroughly. Since, however, we are only concerned here with a subsidiary question which has very little in common with the main question, we consider that we ought merely to mention the essential and special safety measures, without going at length into details and without comment.

Power stations.

Whether the power stations are the property of the railway or of an industrial undertaking, the safety measures indicated in these places are those which are the general rule and consequently do not give rise here to any special remarks. On the whole, it may be said that the administrations, if they buy energy, ought to impose rather strict conditions of supply, with a view to ensuring regular electric operation of the railway both normally and in special circumstances necessitating running numerous special trains.

High-tension lines supplying the substations.

The unilateral feed of the substations is ensured by high-tension lines comprising at least two cables. In order to carry out work, on a line, one of the cables of which is under tension, a minimum distance of 1.50 m. (5 feet) is required between the conductors. To increase the safety, protective frames are set on the top of the pylons. These frames, which are fixed or detachable, separate the two systems from one another or into two groups.

On main arteries, the pylons are constructed with double shafts, so as to provide access to the conductors supported by one of the shafts without danger of coming into contact with the other conductors.

In case of rupture of cables, there are only two compulsory measures known: forbidding workmen to touch them before the line is disconnected and warning the public by suitable notices fixed to each pole.

Substations.

For security of operation of the railway, all the supply circuit breakers of the contact lines are generally extra-rapid or instantaneous-automatic circuit breakers operating in the event of a short circuit or an overload. Before re-connecting a contact line to voltage, the line is tested as a rule with the working voltage by means of a control resistance, so as to obviate the consequences of fresh short circuits if the line is earthed, either on account of a defect or an accident or a mistake on the part of the staff.

Most of the automatic cutting out of the supply circuit is caused by mistakes on the part of the staff, namely: connecting an earthed contact line to voltage, passage of an electric locomotive under an earthed contact line, earthing a live contact line. Generally speaking, such mistakes do not cause any damage to the equipment. Being often observed at the time by the persons who make them, they are rapidly corrected, so that the line is very soon put into a state of service again and may be connected to voltage before the interruption upsets the working. These circumstances have induced the Swiss Federal Railways to introduce automatic operation in their substations. This automatic operation is simple and functions as follows: Every short circuit causes the supply to be interrupted. After about 5 seconds, a control breaker puts a resistance into circuit for about 10 to 60 seconds, this resistance allowing a current of 8 to 20 amperes to pass. If the short circuit disappears in this interval of time, the supply breaker is put in automatically. If the short circuit disappears in this interval of time, the supply breaker is put in automatically. If the short circuit is permanent, acoustic signals are sounded and call up the staff on duty who then proceed to localise

the trouble. Such an installation is not very expensive. It is very economical because it dispenses with the permanent switchboard staff, who may then be assigned to other useful work. In case of trouble on the contact line, the automatic operation ensures immediate control and rapid re-establishment of the normal working condition when the cause of the disconnection has only been momentaneous.

Overhead contact lines.

The normal height of the contact wire above the track varies, irrespective of the working voltage, between 5.50 m. and 6.25 m. (18 ft. 9/16 in. to 20 ft. 6 in.) on open line. Almost everywhere it is 6 m. to 6.25 m. (19 ft. 8 1/4 in. to 20 ft. 6 in.) in stations and at level crossings. The minimum height of the contact wire above the rail is everywhere limited by the regulation clearances with a margin of 5 to 15 cm. (2 to 6 inches) above.

The chief precautionary measures taken for the protection of the railway staff and the public against the dangers of the contact line are the following :

a) All the supports of the contact line, as well as all metal constructions and installations which may accidentally be put under voltage, such as signals, loading cranes, bridges, roofs, signal supports, etc., are connected to the rails which act as an earth. Efficient earthing points are provided at all events at the substations. The use of earthing plates between the latter is not general.

b) At points where the conductor would be easily accessible from above or from the side, protection roofs or trellis and warning notices are set up everywhere.

c) As a general rule, protective devices are not provided at the level crossings to prevent vehicles on the road with loads of excessive height from touching the contact line. The crossing keepers have to see to this. On some railways, protective gauges are provided with a warning notice giving the maximum permissible loading height in places where the contact line is below the normal height.

d) In stations — on platforms and loading places — the attention of the public is drawn to the dangers of the electric conductors by warning plates set up in sufficient number at appropriate places.

e) When loading or unloading wagons standing under a contact line, the latter must always be earthed. The circuit breakers of this line are then locked in their switched-out position. On some railways, all railway stations and substations are provided with special poles for protective earthing of the lines. In other places contact lines which are normally disconnected are earthed by the corresponding circuit breaker.

f) Luminous and acoustic devices indicating whether the contact line is under voltage or not are only installed in the depots.

g) Steam locomotives running under contact lines carry a conventional sign, a warning arrow, reminding the men of the order to manipulate fire tools and the water jet for spraying the coal with the greatest caution and of the prohibition in regard to climbing on the high parts. On some railways, these locomotives carry a metal arch above the front part of the tender to reduce the risk of touching the contact wire with long tools. Coaches and wagons provided with fixed ladders for climbing on to the roof or tanks carry on the ladder a warning plate forbidding the men to ascend them when under contact lines. Elevated look-out boxes should only be occupied when closed.

h) To carry out work on the high tension contact line or in its immediate proximity, the line must always be disconnected and earthed. Gangs at work between two stations may ask for the contact line to be disconnected by means of portable telephones adapted to be con-

nected to the telephone circuit between the stations.

Automatic localisation of disturbances is used, *inter alia* on the St. Gothard line. It appeared necessary at this place because of the importance of the line, the long tunnels and the long distances between the stations. Different systems have been given a trial on other lines with more or less success. Complete automatic installations on contact lines are very costly. They involve expenditure which is not in proportion to their usefulness. Several of these installations have had to be abandoned because they rather aggravated the situation in the case of trouble. Automatic disconnection limited to several coupling circuit breakers and the provision of relays for indicating the passage of the short-circuit current are measures which appear to be the most suitable for localising short circuits.

Third rail.

The measures of protection which are taken in order to avoid any risk of contact on the part of the staff and the public cannot be generalised. They depend upon the places, the type of contact (top, side or bottom) and can scarcely be discussed except with reference to drawings. We shall merely mention that these protective measures consist of guards covering the rail, extra elevation of the platforms, the edge of which may or may not overhang the rail, or if these measures do not suffice, the substitution of a contact line for the third rail.

To carry out work on the third rail under voltage, the men are provided with rubber-soled shoes which afford sufficient protection against low tensions.

When work has to be carried out in immediate proximity to the rail, the latter is covered with planks.

When the rail has to be made dead in order to carry out work, it is compulsory to earth it after the order for disconnecting it has been given.

In case of accident, the rail may be made dead and earthed by means of a short-circuiting device with which each locomotive or rail motor car is equipped.

Locomotives and rail motor cars.

We do not intend to review all the measures taken on the locomotives and rail motor cars for the protection of the staff against the dangers of the current, most of which are special and elementary.

As to those which relate to the safety of working, we would point out that the position of the driver on electric locomotives and the absence of smoke and steam, improve the visibility of the track and signals, and thus considerably increase the safety of working.

Whereas, on the steam locomotive, the stoker often has an arduous task which renders him indispensable, the assistant driver on the electric locomotive has chiefly to help the driver in observing signals and to take his place in case of illness, etc. Thus, the assistant driver has merely to fulfil a safety function. All the railways that have been electrified are also considering more or less the introduction of one-man driving by means of an electro-mechanical safety device, intended to cause the train to stop in case of illness of the driver. The devices which have been tested are based either on the principle of the safety push-button and pedal, on which the driver has to press while the vehicle is running, or on the principle of the safety belt which, countrary to the preceding principle, acts as soon as it exerts a pull on the safety device.

Owing to the objections to which these safety devices still give rise, the practice of having trains driven by one man has so far not become general, but nevertheless it has already been introduced with success on a large scale by some railways. It is limited as yet to trains the speed of which does not exceed 75 km. (43.5 miles) per hour. Other administrations have introduced, as an intermediate measure, either entirely or partly, the practice of

having locomotives driven by one « qualified » man. The assistant driver in this case is replaced by a train employee who, during stops, carries out his ordinary duties.

The installation of these safety devices on locomotives and rail motor cars does not cause any considerable expenditure. Where they are regularly employed, the staff necessary for driving locomotives and motor cars is considerably reduced. The economies thus realised are very important and play a considerable part in the question with which we are concerned. The same applies, to a limited extent, to the practice of having locomotives driven by one qualified man assisted by a train employee.

Most electric trains are heated by electricity in winter. The heating current is provided at the tension of the contact line in cases where traction is with continuous current, and at the tension of 1 000 volts on all railways operated with alternating current. The connection between the locomotive and the vehicles is not provided with any automatic coupling device. The manipulation of the connections should only be effected after cutting off the heating current on the locomotive.

X. — Fatality.

As in any use of heavy, high voltage currents, electrification of railways results in accidents of particular kinds, which we shall call « fatalities ».

According to the information given by 5 administrations, the accidents caused on the average by the electric current are 1.5 per 100 km. (2.4 per 100 miles) of line per year, 1/3 of which have caused the death of the victims, and 2/3 have been more or less serious. Although any accident is to be deplored, and without desiring to detract from the necessity for taking all the measures materially possible to prevent them, we venture to say that the number of accidents connected with electrification is low. Not one of the 5 administrations concerned has had to record up to the present, that is within a period of 10 years, any accident to a passenger caused by electric current. This important fact shows that electric operation itself does not endanger the public using the railway.

In order better to illustrate « fatality » on a large electric system and failing other equally full information, we shall use the statistics of the Swiss Federal Railways, which are included among the five administrations referred to above. These statistics include the accidents occurring during the work of electrification and in electric operation.

Whereas in 1924, when the electrified section of the Swiss Federal Railways only counted 610 km. (379 miles) of line, the number of accidents caused by electric current was 25, that is, 4.1 accidents per 100 km. (6.56 per 100 miles) per year, 13 of which were fatal, that is, 2.1 per 100 km. (3.37 per 100 miles) per year. From 1924 to 1930, the electrified section was extended to 1 666 km. (1 035 miles) without, however, the total number of accidents being increased, except in 1930 when it was 29, that is, 1.75 accident per per 100 km. (3.8 per 100 miles) per year. The number of fatal accidents has never exceeded 13; in each of the last three years, it has been by chance 11, that is 0.66 per 100 km. (1.06 per 100 miles) per year. These figures show that the accident rate has decreased substantially with the extension of the electrification. The figures relate to all the installations of the railway, including the power stations and the transmission lines. However, almost all the accidents take place on the contact lines.

The accidents to persons occurring during the past seven years are divided as follows:

28.5 % in respect of staff employed on the electric installations and particularly in the maintenance of the contact lines.

22 % in respect of station and depot staff.

27 % in respect of the employees of firms carrying out work for the railway.

7.5 % in respect of employees of clients of the railway, engaged in loading and unloading wagons.

6 % in respect of staff of foreign companies.

9 % in respect of suicides.

As to the causes of the particular accidents, we distinguish between those which occur without any fault on the part of the victim; these represent 17 %; 14 % of the injured persons had previously been warned of the danger and had committed some imprudent act; 43 % resulted from the inobservation of written instructions; 19 % were due to the inobservation of general orders and notices; 5 % were the result of mistakes and misunderstandings; 2 % are ascribable to negligence.

This concise review brings out the points where attention is still capable of reducing the number of accidents.

Summary.

1. The rise of large electrically operated lines and their development denote that electrification is satisfactory not only from the technical point of view but also from the economic point of view.

2. The importance of the question of knowing the economic success obtained with electrification increases with the extent of electric undertakings.

3. Progress in the domain of steam locomotives and internal combustion locomotives may retard electrification in some instances, but it may also stimulate progress in the domain of electrification, in particular in the construction of electric motor vehicles, and thus may not definitely lessen the superiority of electric traction over all other systems of traction, from the technical point of view, and consequently also from the economic point of view.

4. A more considerable and more rapid development of electric operation depends to a great extent upon the degree of conviction with which it can be shown that, of the electrifications which have been carried out, the large electrically operated lines are economically profitable for their administration, either directly in the usual sense, or indirectly by ensuring them fairly cheaply the advantages of electric traction.

5. Comparison between the two types of operation cannot alone be the decisive factor, because, for reasons residing in the nature of things, it is affected by some incertitudes, and because it does not include the great and incontestable advantages of electric traction which do not appear distinctly in the accounts.

6. Arithmetical comparison between the two types of operation, electric and steam, elucidates to a large extent the economic problem relating to electrification, for which reason such comparison should be examined by a larger number of administrations.

7. It would appear useful for administrations competent in electric and steam operation, to elucidate the hypotheses and the method to be followed in order to make an arithmetical comparison between the types of operation.

8. The type of energy supply in itself has no decisive influence on the economy of electric operation. The choice of the type depends in the first place upon the particular possibilities and circumstances.

9. The location of the power stations is in most cases determined by the type of supply, by nature and by elementary considerations.

10. The choice of the system has lost its former importance. In many countries, it is limited to the systems already in use or dictated by standards. The system employing continuous current below

1 000 volts, with 3rd or 3rd and 4th rail, has shown itself the best for the electrification of urban and suburban railways. Systems employing continuous current at 1 500 and 3 000 volts and alternating single-phase current at 15 000 volts, 16 2/3 cycles — in America, at 11 000 volts, 25 cycles — are the most widely used and for some time have practically been the only systems to be used for extensive electrification. Two instances of electrification have been carried out experimentally, with a view to the direct utilisation of industrial current, one of which employs three-phase current at 45 cycles and the other three-phase current at 50 cycles.

11. Safety measures have been developed very considerably on all the electrified railways. The cost of safety equipment is of no importance in the economic aspect of electric operation. The economic and moral effect of such equipment is both excellent and considerable.

12. Driving of electric locomotives and rail motor cars by one man is found to be absolutely certain, due to the improvements in safety devices employed for this purpose.

13. In electric operation, the presence of electricity does not diminish the safety of the public using the railway. The accidents caused by the electric current are confined to the staff of the railway, the employees of works' contractors and persons engaged in loading and unloading wagons. Accidents in which the cause is not the infringement of warnings, the failure to observe regulations or orders, or sheer carelessness, are rare.

14. The economic aspect of electric operation remains the principal question in the sphere of electrification, and consequently a well balanced and accurate comparison, from the financial point of view, between electric and steam operation remains of great importance.

TABLE I. — Germany (German State Railways). — Replies to the questionnaire, 1930.

Number of question.	—	Hamburg. Suburban.	Berlin. Suburban.	Central Region.	Silesia.	Bavaria.	Wiesental.	Total.
	Opening of the electric operation	1907	1925-1929	1911	1916	1913, 1925-1929	1913	..
	Type of traffic	Passenger.	Passenger.	Passeng. and goods.	Passeng. and goods.	Passeng. and goods.	Passeng. and goods.	...
1	Length of lines of the railway system. standard gauge. km.	...	...	...	...	...	...	52 894
	Length of lines of the railway system. narrow gauge . km.	...	...	...	...	...	....	927
2	Total length of the electrified lines . km.	33	236	191	348	733	48	1 589
3	Length of the single-track electrified lines. km.	...	9	7	136	273	48	471
4	Length of the double-track electrified lines km.	33	227	184	212	[illegible]	...	1 118
	Length of lines in course of electrification . km.	...	... (1)	...	...	220 (2)	...	220 (2)
7	Length of the electrified tracks . km.	82	588	659	815	1 675	102	3 912
8	Number of tunnels × average length in km.	...	...	...	4×0.3 = 1.2	1×0.05 = 0.05	4.4	5.2
	2 as a percentage of 1	...	...	...	...	...	...	2.95
	8 as a percentage of 2	...	...	...	0.35	...	6.66	0.28
	Distance run annually by all the electric trains in 1 000 km.	3 950	23 700	3 234	4 663	10 264	492	46 303
	Daily trains per kilometre of electrified line	328	276	46.4	36.7	38.3	28.0	79.8
	Gross ton-kilometres of all electric trains hauled, in 1 000 000 ton-kilometres.	802	5 307	1 592	1 920	3 152	71	12 844
	Weight hauled per kilometre of electrified line, in 1 000 metric tons.	24 300	22 445	8 335	5 517	4 300	1 479	8 083
	Average weight of electric trains hauled, in metric tons.	203	224	492	412	307	144	277
[illegible]	Number of passenger train locomotives	...	...	32	30	112	9	183
34	Number of goods trains locomotives	...	...	53	63	70	9	195
38	Number of rail motor cars	140	716	8	21	30	...	915
42	Number of shunting locomotives	1	...	...	...	12	...	13
	Number of all the motor vehicles	141	716	93	114	224	18	1 306

(1) Extension provided for.
(2) 690 km. of track.

TABLE II. — **Austria, Hungary, Czechoslovakia, Switzerland. — Replies to the questionnaire, 1930.**

Number of question.		Austria. — Federal Railways.	Hungary. — State Railways. (being carried out or planned).	Czechoslovakia. — State Railways. (Prague station).	Switzerland. Federal Railways.	Switzerland. Bernese Alps Rys.	Switzerland. Rhaetic Railways.
	Opening of the electric operation	1907-1912, 1914-1918	1924, 1932	1928	1906, 1918-1930	1910-1928	1913-1922
	Type of traffic	Passengers and goods.	Passengers and goods.	Passengers and goods.	Passengers and goods.	Passengers and goods.	Passengers and goods.
1	Length of lines of the railway system. standard gauge. km.	5 825	...	13 500	2 867	240	...
	narrow gauge . km.		...	...	74	...	277
2	Total length of the electrified lines . km.	843	186 (9)	24	1 685 (7)	240 (8)	277
3	Length of the single-track electrified lines . km.	542	...	24	953	213	277
4	Length of the double-track electrified lines . km.	301	186	...	719	27	...
	Length of lines in course of electrification . km.	... (3)	In course (4)	... (5)	76 (6)	...	...
7	Length of the electrified tracks . km.	...	520	70	3 745	336	320
8	Number of tunnels x average length in km.	35	...	1.32	143 — 127	55 — 32.4	82 — 30.8
	2 as a percentage of 1	...	...	0.52	56.83	100.00	100.00
	8 as a percentage of 2	...	...	5.55	7.60	13.50	11.12
	Distance run annually by all the electric trains in 1 000 km.	9 500	3 184	...	30 126	2 370	1 651
	Daily trains per kilometre of electrified line.	30.9	46.9	...	49.3	27.3	16.3
	Gross ton-kilometres of all electric trains hauled, in 1 000 000 ton-kilometres.	2 603	1 284	...	9 935	582	127
	Weight hauled per kilometre of electrified line, in 1 000 metric tons.	3 088	6 903	...	5 942	2 425	460
	Average weight of electric trains hauled, in metric tons.	274	403	...	330	246	77
30	Number of passenger train locomotives	194 (1)	...	8	299	33	30
34	Number of goods train locomotive			10	55		
38	Number of motor cars	25 (2)	...	...	46	11	...
42	Number of shunting locomotives	...	...	accumul. 4	23	...	...
	Number of all the motor vehicles	219	36	22	423	44	30

(1) 178 normal gauge, and 16 narrow gauge.

(2) 15 normal gauge, and 10 narrow gauge.

(3) 4 projected, in all 743 km.

(4) 9.5 km. worked since 1924.

(5) Extension projected.

(6) According to the programme fixed, another 428 km. to be electrified, not including 5 km. operated by BT.

(7) Including 13 km. operated by Swiss Federal Railways but belonging to Bernese Alps Railways and not included in (8).

(9) 9.5 km. in trial operation, since 1928, with one locomotive.

Table III. — Switzerland, 1930.

	Length of lines operated in 1930, in kilometres.					Traffic in 1 000 000 of gross ton-kilometres.			
	Total. *a*	Steam. *b*	Electricity. *c*	*c* as a °/₀ of *a*. *d*	Electrification in course. *e*	Total. *f*	Steam. *g*	Electricity. *h*	*h* as a °/₀ of *f*. *i*
Swiss Federal standard gauge	2 868	1 121	1 747	60.9	70	9 783 (1)	1 419 (1)	8 364 (1)(4)	86 (3)
Other railways	835	373	462	55.3	60	677 (2)	178 (2)	499 (2)	74
Standard gauge railways	3 703	1 494	2 209	59.7		10 460	1 597	8 863	85
Swiss Federal, narrow gauge	74	74	...	0.0		39 (1)	39 (1)	...	0
Other railways	1 600	271	1 329	83.6		383 (2)	33 (2)	350 (2)	95
Narrow gauge railways	1 674	345	1 329	79.4		422	72	350	84
Rack railways	117	45	72	61.5		4.3	1.4	3	66
All railways	5 494	1 884	3 610	65.7		10 886	1 670	9 216	85

(1) According to the statistics of 1927.
(2) According to the statistics of 1926.
Proportions practically constant fort several years.
(3) Approximate percentages for 1930, rather a little too low.
(4) The figure for 1930 is 9 935 millions of gross ton-kilometres.

TABLE IV

Serial number.	Number of question. *	1	Hamburg Suburba[n] 2
1	9	Annual distance run by passenger trains, in 1 000 km.	3 950
2	12	— — goods trains, in 1 000 km.	...
3		— — all trains, in 1 000 km.	3 950
4		Number of trains per day and per km. of electrified line	328
5	11	Gross ton-kilometres of passenger trains hauled, in 1 000 000 of ton-kilometres.	802
6	14	Gross ton-kilometres of goods trains hauled, in 1 000 000 of ton kilometres	...
7		Gross ton-kilometres of all trains hauled, in 1 000 000 of ton-kilometres.	802
8		Gross ton-kilometres hauled per kilometre of electrified line, in 1 000 of ton-kilometres.	24 300
9		Average weight of passenger trains hauled, in metric tons	230
10		Average weight of goods trains hauled, in metric tons	...
11		Average weight of all trains hauled, in metric tons	230
12	10	Annual distance run by passenger train locomotives, in 1 000 of km. .	...
13		Annual distance run by passenger train rail motor cars, in 1 000 of km.	11 130
14	13	Annual distance run by goods trains locomotives, in 1 000 of km. . .	...
15		Annual distance run by goods train rail motor cars, in 1 000 of km. .	...
16		Annual distance run by locomotives and rail motor cars of all trains, in 1 000 of km.	11 130
17		Gross ton-kilometres hauled on the average per locomotive and train rail motor car, in 1 000 of km.	5 730
18		The sum of the locomotive-kilometres and of the rail motor car-kilometres divided by the km. run by all the trains.	2.86
19	30	Number of passenger train locomotives	...
20	34	Number of goods train locomotives	...
21	38	Number of rail motor cars	140
22	42	Number of shunting locomotives	1
23		Number of all the motor vehicles	141
24	46	Annual average distance run by passenger train locomotives, in km. per locomotive.	...
25		Annual average distance run by goods train locomotives, in km. per locomotive.	...

* In questionnaire.

rmany.

Berlin Suburban. 3	Central Region. 4	Silesia. 5	Bavaria. 6	Wiesental. 7
23 700	2 080	3 038	7 378	412
...	1 154	1 625	2 886	80
23 700	3 234	4 663	10 264	492
276	46.6	36.7	38.3	28.0
5 307	573	700	1 685	57
...	1 019	1 220	1 467	14
5 307	1 592	1 920	3 152	71
22 445	8 335	5 517	4 300	1 479
224	275	290	229	139
...	883	750	508	175
224	492	412	307	144
...	2 027	2 164	6 499	460
74 000	601	1 166	2 717	...
...	1 750	2 304	2 882	152
...	...	...	4	...
74 000	4 378	5 634	12 102	612
7 410	17 120	16 850	14 870	3 940
3.32	1.37	1.21	1.20	1.24
...	32	30	112	9
...	53	63	70	9
716	8	21	30	...
...	...	...	12	...
716	93	114	224	18
...	45 000	48 000	53 000	54 000
...				

TABLE IV.

Serial Number	Number of question *	1	Hamburg Suburban 2
26		Annual average distance run by rail motor cars, in km. per motor car.	79 300
27		Annual average distance run by train locomotives and rail motor cars, in km. per locomotive.	79 300
28		Annual average distance run by shunting locomotives, in km. per locomotive.	...
29	119	Type of traction current, voltage	Sing.-ph., 25, 6 000
30		Type of the most powerful passenger train locomotive	
31	31	Total weight/Adhesion weight, in metric tons	
32	32	Hourly power, in kw. or H. P.	—
33	33	Hourly tractive effort, in kgr.	
34		Type of the most powerful goods train locomotive	
35	35	Total weight/Adhesion weight, in metric tons	
36	36	Hourly power, in kw. or H. P.	
37	37	Hourly tractive effort, in kgr.	
38		Type of the most powerful rail motor car	
39	39	Total weight/Adhesion weight, in metric tons	
40	40	Hourly power, in kw. or H. P.	
41	41	Hourly tractive effort, in kgr.	
42		Type of the most powerful shunting locomotive	
43	43	Total weight/Adhesion weight, in metric tons	
44	44	Hourly power, in kw. or H. P.	
45	45	Hourly tractive effort, in kgr.	
		Driving of motor vehicles.	
46	47	Locomotives	...
47	48	Rail motor cars	Pooled.
48	49	Normal staff of train locomotives	2
49	50	Number of train locomotives driven by one man	...
50	51	Normal staff of rail motor cars	2
51	52	Number of drivers and assistant drivers for all the motor vehicles	172
52	53	Drivers and assistant drivers per locomotive or per rail motor car	1.23
53	55	Approximate number of steam locomotive necessary for the same traffic	...
54	54	Number of drivers and stokers in steam operation	...
55	56	Drivers and stokers per steam locomotive	...

* In questionnaire.

any (*continued*).

erlin Suburban. 3	Central Region. 4	Silesia. 5	Bavaria. 6	Wiesental. 7
103 400	75 000	56 000	91 000	...
103 400	75 000	49 400	57 100	...
...	...	...	42 000	...
D. C., 800	Sing.-ph., 16 2/3, 15 000	Sing.-ph., 16 2/3, 15 000	Sing.-ph., 16 2/3, 15 000	Sing.-ph., 16 2/3, 15 000

No. 17, 1 Do 1
110/80
2 800 kw. (J. E. C.) at 89 km./h., max. 110 km./h.
11 500 kgr. at the motor shaft, 11 300 at the rim.

No. E 95, 1 Co—Co 1
139/116
2 715 kw. (J. E. C.) at 49 km./h., max. 65 km./h.
20 000 kgr. at the rim.

No. E 7, Bo — 2
60/28
545 kw. (J. E. C.) at 66 km./h., max. 75 km./h.
3 100 kgr. at motor shaft, 3 050 kgr. at the rim.

No. E 60, 1 C
73/58
1 090 kw. (J. E. C.) at 38.8 km./h., max. 55 km./h.
10 300 kgr. at motor shaft, 9 800 kgr. at the rim.

... Pooled.	Regular drivers.	Regular drivers.	Regular drivers.	Regular drivers. ...
2	2	2	2	2
...	On trains running at 75 km./h. max., one of the men acts as driver.			...
	Shunting locos: 2	...	Shunting locos: 12.	...
2	2	2	2	...
990	263	225	379	21
1.32	2.82	1.97	1.79	1.17
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...

TABLE IV

Serial number.	Number of question. *	1	Hamburg Suburba[n] 2
		Maintenance costs of motor vehicles.	
56	57	Maintenance of locomotives per km. run	...
57		— — per 1 000 gross tkm. hauled	...
58	58	Maintenance of rail motor cars per km. run	...
59		— — per 1 000 gross tkm. hauled	...
60	59	Maintenance of steam locomotives for an equivalent traffic and operation, per km. run.	...
61		Maintenance of steam locomotives for an equivalent traffic and operation, per 1 000 gross tkm. hauled.	...
		Availability of motor vehicles.	
62	60	Electric locomotives, per cent of the time	...
63	61	Electric, rail motor cars, per cent of the time	93
64	62	Steam locomotives, per cent of the time	...
		Cost of staff.	
65	74	Average cost of a driver	
66	75	— an assistant driver	
67	76	— an unskilled workman	
		Fuel for steam operation.	
68	66	Fuel available for steam operation	German coal.
69	71	Calorific power on the grate, in kgr. calories per kgr.	Ruhr coal:
70	70	Approximate price of fuel taken at the mine	Ruhr coal:
71		— — carriage free to the frontier	...
72		— — carriage free to the depot	...
73		— — carriage free on the tender	...
74	73	Cost of transport, per metric ton and per km.	...
		Electric energy.	Own power sta[tion]
75	77	Available energy, in kw.-h.	Steam, 158.10⁶
76		Maximum power available, in kw.	18 000
77	114	Type of current at the input of the substations	Sing.-ph. 25, 30
78	80	Consumption of energy for traction, in kw.-h.	44.10⁶
79		Maximum power required by traction, in kw.	...
80	81	Consumption of energy, per train-kilometre, in kw.-h.	11.1
81	82	— — per gross tkm., in w.-h.	55
82	83	Price of energy at the point of supply to the contact line	...
83	84	— — at the input to the substations	..
84	85	— — at the output of the power station or at the place of delivery of bought energy, Rpf. per kw.-h.	5.8
85	78	Number of substations	1
86	79	Length of line per substation, in km.	33

* In questionnaire.

...many (*continued*).

...erlin Suburban. 3	Central Region. 4	Silesia. 5	Bavaria. 6	Wiesental. 7
...	No. E 16 (express), 0.199 Rm.; No. E 95 (goods), 0.342 Rm.			
...	...	...	...	...
0.045 Rm.	0.147 Rm.	RM. 0.147	RM. 0.147	...
...	...	...	...	...
No. 77, 0.321 Rr.; No. 18[5] (express), 0.295 Rm.; No. 58[10-22] (goods), 0.446 Rm.				
...	...	...	...	...
...	75	58	70	60
91	...	76	90	...
...	...	...	...	...
6 850 Rm. per year.				
5 720 Rm. per year.				
1.05 Rm. per hour.				
German coal.	German coal.	German coal.	German coal.	German coal.
...00 kgr./cal. per kgr.		Silesian coal: 6 900 kgr./cal. per kgr.		
...30 Rm. per metric ton.		Silesian coal: 16.90 Rm. per metric ton.		
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
Purchased.	Own power stat.	Own power stat.	Purchased.	Purchased.
As required.	Steam, 90.10^6	Steam, 210.10^6	Hydraulic, 250.10^6	Hydraulic, 12.10^6
...	22 000	24 000	88 000	1 300
...phase 50, 30 0000	Sing.-ph. 16 2/3, 60 000	Sing.-ph. 16 2/3, 80 000	Sing.-ph. 16 2/3, 110 000	3-phase 50, 6 500
285.10^6	43.10^6	62.10^6	116.10^6	8.10^6
...	...	...	...	...
12.0	14.4	20.2	11.3	15.9
53.5	23.0	32.0	36.7	110.0
...	...	...	...	...
...	...	...	...	...
2.87	3.20	2.57	2.62	1.52
48	3	3	5	1
City: 0.94 Circle: 1.61 Suburban: 8.46	50	55	62	48

TABLE IV

Serial number.	Number of question. *	1	Austria. Federal Rys. 8
1	9	Annual distance run by passenger trains, in 1 000 km.	6 300
2	12	— — goods trains, in 1 000 km.	3 200
3		— — all trains, in 1 000 km.	9 500
4		Number of trains per day and per km. of electrified line	30.9
5	11	Gross ton-kilometres of passenger trains hauled, in 1 000 000 of ton-kilometres.	1 154
6	14	Gross ton-kilometres of goods trains hauled, in 1 000 000 of ton kilometres.	1 449
7		Gross ton-kilometres of all trains hauled, in 1 000 000 of ton-kilometres.	2 603
8		Gross ton-kilometres hauled per kilometre of electrified line, in 1 000 of ton-kilometres.	3 088
9		Average weight of passenger trains hauled, in metric tons	183
10		Average weight of goods trains hauled, in metric tons	453
11		Average weight of all trains hauled in metric tons	274
12	10	Annual distance run by passenger train locomotives, in 1 000 of km.	...
13		Annual distance run by passenger train rail motor cars, in 1 000 of km.	...
14	13	Annual distance run by goods trains locomotives, in 1 000 of km.	...
15		Annual distance run by goods train rail motor cars, in 1 000 of km.	...
16		Annual distance run by locomotives and rail motor cars of all trains, in 1 000 of km.	12 000
17		Gross ton-kilometres hauled on the average per locomotive and train rail motor car, in 1 000 of km.	12 390
18		The sum of the locomotive-kilometres and of the rail motor car-kilometres divided by the km. run by all the trains.	1.36 (Actually a little less).
19	30	Number of passenger train locomotives	169
20	34	Number of goods train locomotives	
21	38	Number of rail motor cars	Stand. g. 15 Narr. g. 10
22	42	Number of shunting locomotives	...
23		Number of all the motor vehicles	Stand. g. 178 Narr. g. 16
24	46	Annual average distance run by shunting locomotives, in km. per locomotive.	66 200
25		Annual average distance run by shunting locomotives, in km. per locomotive.	
26		Annual average distance run by rail motor cars, in km. per motor car.	69 700

* In questionnaire.

ued).

Czechoslovakia. State Rys. 9	Switzerland. Federal Rys. 10	Switzerland. Bernese Alps Rys. 11	Switzerland. Rhætic Rys. 12
...	19 810	1 979	...
...	9 853	391	...
...	29 663	2 370	1 651
...	48.2	27.3	16.3
...	4 725	...	...
...	5 210	...	...
...	9 935	582	127
...	5 896	2 425	460
...	237	...	...
...	528	...	...
...	334	246	77
		1 311	
485	30 149	669	1 850
0	3 010	387	
		5	...
485	33 159	2 372	1 925
...	24 300	13 230	4 230
...	1.12	1.08	1.17
8	On the average 297	33	30
10	do. 55		
...	do. 55	11	...
4 accum. —	do. 23	...	...
(22) 18	430	44	30
...	85 200	56 000 approx.	64 161 Type CC 76 699
...	54 700	63 700 "	...

TABLE IV

Serial Number.	Number of question. *	1	Austria. Federal Rys. 8
27		Annual average distance run by train locomotives and rail motor cars, in km. per locomotive.	64 600
28		Annual average distance run by goods train locomotives, in km. per locomotive.	42 700
29	119	Type of traction current, voltage	Sing.-ph. 16 2/3, 15
30		Type of the most powerful passenger train locomotive	1 Do 1
31	31	Total weight/Adhesion weight, in metric tons	104/70
32	32	Hourly power, in kw. or H. P.	2 670 H.P. at the
33	33	Hourly tractive effort, in kgr.	11 360 kgr. —
34		Type of the most powerful goods train locomotive	E
35	35	Total weight/Adhesion weight, in metric tons	82/82
36	36	Hourly power, in kw. or H. P.	1 810 H.P. at the
37	37	Hourly tractive effort, in kgr.	14 550 kgr. —
38		Type of the most powerful rail motor car	E T 10
39	39	Total weight/Adhesion weight, in metric tons	78/30
40	40	Hourly power, in kw. or H. P.	680 H.P. at the
41	41	Hourly tractive effort, in kgr.	9 430 kgr. —
42		Type of the most powerful passenger train locomotive	D
43	43	Total weight/Adhesion weight, in metric tons	56/56
44	44	Hourly power, in kw. or H. P.	905 H.P. at the
45	45	Hourly tractive effort, in kgr.	9 430 kgr. —
		Driving of motor vehicles.	
46	47	Locomotives	Working table.
47	48	Rail motor cars	Working table.
48	49	Normal staff of train locomotives	[illegible]
49	50	Number of train locomotives driven by one man	...
50	51	Normal staff of rail motor cars	2
51	52	Number of drivers and assistant drivers for all the motor vehicles . .	...
52	53	Drivers and assistant drivers per locomotive or per rail motor car . .	...
53	55	Approximate number of steam locomotives necessary for the same traffic.	...
54	54	Number of drivers and stokers in steam operation	...
55	56	Drivers and stokers per steam locomotive	...

* In questionnaire.
** There are a large number of these, but also 2 more powerful locomotives, 1 Bo 1 Bo 1 + 1 Bo 1 Bo 1; total w

ued).

Czechoslovakia. State Rys. 9	**Switzerland.**			
	Federal Rys. 10	**Bernese Alps Rys.** 11	**Rhætic Rys.** 12	
...	81 100	58 000 approx.	64 161	
...	34 400	...	...	
D. C. 1 500 V.	Single-ph. 16 2/3, 15 000	Single-ph. 16 2/3, 15 000	Single-ph. 16 2/3, 11 000	
1 Do 1	2 Do 1**			
86/66	118/77			
550 kw. at the rim.	2 800 H.P., 65 km./h. max. 100 km./h.	1 C+C 1	C+C	
500 kgr. —	11 700	142/114	68/68	
Bo+Bo	1 C+C 1	4 500 kgr. at the rim.	1 200 H.P. at motor shaft.	
65.4/65.4	131/109	24 000 kgr. —	9 700 kgr. at the rim.	
260 kw. at the rim.	2 460 H.P. at 35 km./h.			
700 kgr. —	19 000 kgr. at the rim.			
...	Bo+Bo	...	...	
...	65/65	74/62	...	
...	1 350 H.P. at 48 km./h.	1 600 H.P. at the rim.	...	
...	7 500 kgr. at the rim.	8 000 kgr. —	...	
210 kw.	C	...	...	
6 000 kgr.	...	...	...	
Bo+Bo	620 H.P. at 29 km./h.	...	...	
67.5/67.5	5 750 kgr. at the rim.	...	...	
...	In principle, pooled.	Pooled.	Pooled.	
...	Actually, pooled and regular sets of men.	Pooled.	...	
2 (of which 1 guard)	1 or 2	1 or 2	1	
...	220 (out of 377)	18	30 (all)	
...	1	1	...	
54	1 690 approx.	94	64	
2.46	4.00 approx.	2.10	1.97	
...	660	65 à 70	66	
...	2 500 approx.	200 approx.	168 approx.	
...	3.80 approx.	3.00 approx.	2.55	

dhesive weight 160 t.; 8 800 H.P. at 62 km./h.; tractive effort, 40 000 kgr. at the rim.

TABLE IV

Serial Number.	Number of question.*	1	Austria. Federal Rys. 8
		Maintenance costs of motor vehicles.	
56	57	Maintenance of locomotives per km. run	...
57		— — per 1 000 gross tkm. hauled	...
58	58	Maintenance of rail motor cars per km. run	...
59		— — per 1 000 gross tkm. hauled	...
60	59	Maintenance of steam locomotives for an equivalent traffic and operation, per km. run	...
61		Maintenance of steam locomotives for an equivalent traffic and operation, per 1 000 gross tkm. hauled	...
		Availability of motor vehicles.	
62	60	Electric locomotives, per cent of the time	...
63	61	Electric rail motor cars, per cent of the time	...
64	62	Steam locomotives, per cent of the time	...
		Cost of staff.	
65	74	Average cost of a driver	...
66	75	— an assistant driver	...
67	76	— an unskilled workman	...
		Fuel for steam operation.	
68	66	Fuel available for steam operation	Bohemian coal
69	71	Calorific power on the grate, in kgr.-calories per kgr.	...
70	70	Approximate price of fuel taken at the mine	...
71		— — carriage free to the frontier	...
72		— — carriage to the depot	...
73		— — carriage free on the tender	...
74	73	Cost of transport, per metric ton and per km.	...
		Electric energy.	Own stat. and pu
75	77	Available energy, in kw.-h.	Hydraulic, 150-200
76		Maximum power available, in kw.	...
77	114	Type of current at the input of the substations	Sing.-ph. 16 2/3, 50
78	80	Consumption of energy for traction, in kw.-h.	133.10^6
79		Maximum power required by traction, in kw.	—
80	81	Consumption of energy, per train-kilometre, in kw.-h.	West of Salzburg Salzkammergut
81	82	— — per gross tkm., in w.-h.	West of Salzburg Salzkammergut.
82	83	Price of energy at the point of supply to the contact line	...
83	84	— — at the input to the substations	...
84	85	— — at the output of the power station or at the place of delivery of bought energy, Rpf. per kw.-h.	...
85	78	Number of substations	West of Salzburg
86	79	Length of line per substation, in km.	West of Salzburg Salzkammergut

* In questionnaire.

inued).

Czechoslovakia. State Rys. 9		Switzerland. Federal Rys. 10		Switzerland. Bernese Alps Rys. 11	Switzerland. Rhætic Rys. 12
...		21.23 c. (Sw.)		50.30 c. (Sw.)	25.30 c. (Sw.)
...		68.50 —		...	...
...		26.00 —		36.00 c. (Sw.)	...
...		202.00 —		...	...
...		37.00 c. approx.		60 to 70 c. (Sw.)	29.6 c. Sw. approx.
...		126.00 c. approx.		...	...
...		90 approx.		80 approx.	80.4
...				90 —	...
...		73 —		67 —	57.0 (estimated)
23 850 Kô. per year (salary).		9 640 Sw. frs. per year.		9 300 Sw. frs. per year.	10 814 Sw. frs. per year.
...		6 240 — —		7 700 — —	9 410 — —
13 320 Kô. per year (wages).		5 000 — —		5 000 — —	4 885 — —
Bohemian coal and lignite.		Imported coal.		See Swiss Fèderal Rys. (transport distance longer).	
300-5 800	3 700-6 800	7 600	7 640		
Average coal.	Average lignite.	Coal.	Briquettes.		
173 Kô.	81 Kô.	22.60 frs.	20.25 frs.		
...	...	35.00 frs.	33.50 frs.		
195 Kô.	102 Kô.	...	...		
[illegible] Kô.	107 Kô.	40.00 frs.	38.50 frs.		
.667 Kô. per metric ton + 0.0654 per tkm.		Approx. 1.20 c. per gross tkm.			
Purchased.		Own stations and purchased.		Purchased.	Purchased.
Steam.		Hydraulic, 573.10^6		Hydraulic, 170.10^6	Hydraulic, $21.9.10^6$
...		197 000		238 000	10 000
3-phase 50, 22 000		Single-ph. 16 2/3, 66 000		Single-ph. 16 2/3, 15 000	Single-ph. 16 2/3, 11 000
$4.2.10^6$		472.10^6		$28.5.10^6$	$16.2.10^6$
...		110 000		15 400	7 800
...		15.6		12.0	8.8
...		47.46		48.8	60.23
...		Cts. 4.77 c.		3.4 to 7.5 c.	7.10 c.
0.35 Kô. per kw.-h.		— 3.85 c.		...	...
...		Own stations 2.54 Purchased: 5.92		...	...
1		Substations: 22 Supply stations: 6		Supply stations: 3	Supply stations: 3 92
24		70 approx.		36 to 40	Intervals 62, 54, 79.

[656. 212.6 & 656. 225]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

12th SESSION (CAIRO, 1933).

QUESTION VIII:

Organisation for carrying small consignments of goods and the most suitable methods for their delivery with the least delay. Use and selection of fixed and mechanical transhipping plants [1],

REPORT No. 1

(Belgium, France, Spain, Holland, Portugal and their Colonies, Switzerland, Denmark, Finland, Luxemburg, Norway and Sweden),

by Mr. HAUTERRE,
Chef de l'exploitation adjoint, French State Railways.

and Mr. MERMONT,
Inspecteur général du mouvement, French Est Railway.

OUTLINE OF THE REPORT

In this report we shall examine the question of the conveyance of parcels by fast and slow trains.

Certain remarks of a general nature and certain considerations bearing mainly on procedure at the arrival and departure stations, are applicable whatever particular mode of conveyance is dealt with; in order to avoid useless repetition we have collected these in a single chapter.

On the other hand, it seemed to be helpful to treat separately those questions dealing with the organisation of transport by fast and by slow trains since the guiding principles often vary in these two cases.

The question of the choice of appliances for use in the handling of parcels traffic appeared to be worthy of special treatment.

Finally — and in concluding this survey — we will indicate what, in our opinion, is the direction in which the Railways should now turn their efforts in order to improve the methods of handling parcels traffic.

CHAPTER I.

Considerations affecting equally transport by fast and by slow trains.

1. **Definition of the term « Parcels ».**

Leaving on one side questions of charges which vary between countries and even between railway systems, we shall adhere to the following definition,

(1) Translated from the French.

which moreover is common to all the replies received :

A « parcel » is a package which may be handed in for conveyance without any previous notification and the handling of which falls on the railway.

It should be pointed out that in some countries the maximum weight of a parcel is strictly limited, 250 kgr. (550 lb.) for example. In other countries it is stipulated only that parcels should be capable of « easy loading ».

In other cases where, for example, wayside stations with small staffs are concerned, the regulations stipulate a maximum weight per package and require that the consignors should lend assistance in the loading.

2. Time « en route ».

The time for delivery is usually fixed by regulation according to the length of the journey — one day for each multiple of n km. The value of n is approximately 300 km. (186 miles) for express trains and 100 km. (62 miles) for slow trains.

The railway company is in addition allowed a certain margin for collection and delivery.

Some countries, such as Spain, Portugal and France, fix their time for delivery by fast trains according to the scheduled running of those trains by which parcels are conveyed. These trains are selected according to the time at which the package is handed in and it should be delivered to the consignee a given number of hours after the arrival of the last of the stated trains.

The penalties set down in the event of the stated times being exceeded consist of the payment of an indemnity. This may be contractual (total or partial refund of the charges — rates reduced to those for carriage by slow train) or it may represent compensation for the actual damages incurred by the customer.

The object of these penalties is to encourage the Railway to observe the fixed delivery times.

But there is another factor which stimulates it more and more to reduce these times and that is the competition of road transport. Parcels traffic is liable to fall an easy prey to road transport undertakings. The principal factors favouring road transport may be summarised as : door-to-door collection and delivery of parcels, rapidity of conveyance, guarantee that amount of handling will be reduced to a minimum and that, consequently, risks of damage will be reduced, canvassing by road transport agents always in search for customers, simplification and often absence of formalities, the fact of being able to bargain with the contractor who, if necessary, will not hesitate to reduce his rates in order to secure the traffic and to make concessions which a railway administration could not entertain.

One of the most effective means of retaining its traffic which a railway company can employ is by increasing the speed of the traffic.

3. Facilities offered to customers.

In order to fight road competition railways have been led to offer more facilities to the public. With this object in view they have opened in the majority of big towns, depots which they either manage by themselves or by people not employed by the companies. Consignors can have the same service there as at the stations. These depots are visited by vans which convey the parcels to the stations. This provision relieves customers of tiresome journeying to and from stations, but as a rule, it is not particularly helpful as regards accelerating handling. Indeed, unless the depot is one whose importance is such as to justify frequent clearings, packages are removed only once or twice daily; they are then not available for dispatch by all suitable trains; thus there is a drawback attached to this method, particu-

larly where express parcels are concerned.

The railways have also organised in the big towns services of door-to-door collection.

The consignor makes a telephonic or written request for a call to be made at his premises.

The various replies which we have received shew that on the whole these services are poorly patronised. This is no doubt due to the fact that the greater number of traders possess, for other purposes, their own vehicles and drivers which they find it advantageous to use for their dealings with the railway company.

On the other hand we will describe the interesting results obtained by the intermediary of collecting agencies. These agencies, under agreed arrangements, undertake the transport of merchandise between say, two big towns. They collect the goods from the senders with whom they are under agreement, and they have the advantage from the point of view of the railway company of being a single consignor. They are thus in a position to provide full wagon loads. The railway can in consequence effect appreciable economies, and is able to grant reduced rates to the agencies which in turn enable the latter to offer lower charges to their clients than those made by their road transport competitors.

4. Formalities in connection with the dispatch of marchandise.

When a consignment of goods is handed in to the railway, it must be checked over, by comparing it with the waybill, and the nature, number and weight of the packages verified. The sender is as a rule responsible for labelling the goods. Certain companies consider this labelling to be sufficient (the Federal Swiss Railways, the Swedish State Railways and the State Railways of Finland are included amongst these). Other companies consider it necessary themselves to undertake the labelling in which the names of the dispatching and receiving stations are given, and if occasion demands the route to be followed.

It may be observed that the necessity for careful labelling is especially necessary for fast trains. Indeed, on account of the large number of packages conveyed in a single wagon and the short period available for dealing with them, it is often impossible to compare the articles with their respective waybills; consequently reliance must be placed upon the labels.

The most logical solution of the problem would be, no doubt, to discriminate between those packages requiring no intermediate handling and those requiring transhipment. It is obvious, for example, that if a wagon full of goods leaves a big station A daily for a single station B, it is not indispensable that station A should label these packages.

Wagons containing goods for various destinations are usually labelled. Several companies use on such wagons different labels from those affixed to wagons fully loaded for a single destination, the contents of which are handled by the public. These labels are distinguishable either by their colours, their shape or by conventional signs which indicate the purpose of the wagon and often the trains in which it will travel.

Such a differentiation appears to us highly desirable, it being of considerable utility in that it enables the staff to pick out rapidly the « varied destination » wagons and permits :

— the shunters to place these wagons easily in the trains, and to put them expeditiously in the sidings at their destination or tranship station for unloading,

— the cartage contractors to find rapidly in trains stopping at the station, the various wagons for loading or unloading.

At the originating station, the office

work should be organised so that the labels are prepared early enough to avoid delaying the dispatch of goods.

5. Steps taken to simplify routine.

After the checking of the packages, the waybills are sent to the office where the various documents are prepared. The company usually has to supply the consignor with a receipt, which in some countries must shew the charges made. In some countries (Portugal, Sweden, Denmark) the charge is not calculated on acceptance if the goods are sent carriage forward. In this manner the consignor does not spend so much time in formalities. In practice, even in those countries where the company is obliged to mark the charges on the receipt, the time gained is not always of much value because many customers do not wait for the receipt, but receive it later on.

Other more efficacious measures have been adopted in certain cases to simplify the formalities at dispatch. The following may be quoted :

Postal packages. — The charges for these are based upon their weight irrespective of length of journey. The customer pays the carriage when he obtains the postal voucher and his receipt is handed to him.

Express parcels. — These are consigned in a similar manner to passenger luggage with a minimum of formalities at dispatch.

In the case of certain articles direct transference by the sender from road to railway vehicle is permitted, for instance, fresh fish, when the harbour sidings are situated some considerable distance away from the dispatch shed. Checking and particularly weighing are in these cases difficult; all that can be done is to make an estimate of the weight at the departure or arrival station.

6. Procedure at the arrival station.

Immediately after the unloading of the goods they must be identified, that is to say, compared with the waybills. After this, the documents are sent to the rates office where the charges are checked or made out and the consignees notified.

The goods themselves are sorted out in the arrival depot and kept ready for the consignee. In some localities of sufficient importance, the railway has established delivery services which are generally made greater use of than the collection services.

Moreover, some administrations arrange, when requested, for an express delivery to the customer's premises, for which a special rate is charged. In such cases the goods are delivered a few hours after their arrival at the depot.

If the goods are to be delivered at the depot, the consignee is advised by telephone or by messenger of their arrival.

CHAPTER II.

Organisation of transport by fast trains.

7. Trains used for the conveyance of express parcels.

Express parcels are often conveyed by passenger trains. The fastest trains are usually not made use of for these services because of the delay occasioned by the handling of the goods. Nevertheless, the ever-increasing demand for the rapid conveyance of goods has led in some cases to the use of these trains for certain perishable traffic, such as fish.

Stopping trains are then generally employed for the conveyance of *express* goods. The running of these trains is on this account often adversely affected which is one reason why such trains are losing passengers on branch lines.

On the more important lines, these trains have continued to be run at a sufficiently high average speed and regularity of running adversely affected by the daily traffic variation has been ensured by using suitably timed goods

trains for the conveyance of part or all of the express parcel traffic.

It is worth noting that these goods trains, even when they travel slowly, often convey the goods more expeditiously than the stopping trains, the time-table of which is subordinated to the needs of the passengers.

If one considers, for example, the intermediate section AB of a main line XY, it is evidently not served at all at night by any stopping train. Goods leaving X

X A B Y

in the evening intended for Y will stop somewhere along AB, whilst even a slow goods train, covering the whole distance XY will procure, in general, a more rapid conveyance.

On lines of medium importance, semi-stopping goods trains can be used, particularly on those branches serving main lines. On these main lines it is often possible only to run fast goods trains.

It is usually required that these trains should start after a certain time and arrive at their destination before a certain time; such is the case with trains of food stuffs for the big consuming centres. Since consignors always ask that their goods should leave at the latest possible time and consignees desire that they should arrive at the earliest possible time, it is often imperative to run the trains at a speed comparable with that of expresses.

8. Wagons used for « express » goods.

The brake vans of passenger trains are often used for the carriage of express goods. Other vehicles are however often employed principally to avoid transhipment and its inconveniences at terminal stations where passenger trains interconnect.

These are « special-duty » wagons whose use is brought to the knowledge of those concerned by special instructions. These are drawn up as a result of a study of the currents of traffic which traverse the system, with the principal object of avoiding transhipments which result in loss of time and in labour charges and which increase the risks of damage.

A G_1 B C G_2 D

Supposing that whilst studying the traffic from a station G_1 situated on a section AB, it is noticed that the goods originating there daily and having a destination G_2 on a section CD justify the use of a wagon between G_1 and G_2. Station G_1 will load a « full » wagon daily for G_2. This wagon will generally leave G_1 sealed and will not require any attention in the course of the journey. The instructions mentioned above specify the various trains to be used for its haulage. Similar wagons travel daily between the principal centres of a system or of neighbouring systems.

The calculation of the tonnage necessary to justify putting a « reserved » wagon into service depends on several factors. It is necessary to reconcile the need for rapid transit and consequent reduction of transhipments with the desire to use the rolling stock economically; the sacrifices which can be made with the latter object in view depend obviously on the available supply of *rolling stock*. It should be remarked that it may be logical to adopt various solutions according to the flow of traffic; if the utilisation of a *reserved* wagon avoids several transhipments, it might be worth while to authorise it even for a smaller tonnage than in the case where only a single transhipment would be avoided. Likewise for certain traffic proceeding from a district frequently having a surplus of stock to one normally having a shortage, it would be policy to accept a *reserved* wagon for the outward direction but not for the inward direction. The maximum tonnage required for the provision of *re-*

served wagons is usually between 2 and 3 tons. This may be lowered in the case of light goods on condition that the wagon is filled.

Returning to the imaginary case mentioned above and supposing that station G_1 can supply on certain days only the specified tonnage for a reserved wagon between G_1 and G_2, nevertheless G_1 would generally be instructed to utilise such occasional reserved wagons on those eligible days.

It may also happen that station G_1 normally has a considerable tonnage of goods, not for station G_2 but for the stations in general in section CD. The instructions provide in this case for the *regular* running of a *distributing* wagon which goes from G_1 direct to C and thence distributes its load on the journey from C to D. In order to expedite this distribution, the originating station ought to sort the packages into lots for the individual stations and, moreover, these lots should be arranged according to the geographical order of the stations. In order that this work may be effectively performed it is, of course, necessary that the responsible staff should know the correct order of the stations. Their duties are facilitated if all the documents are clearly written.

The necessity for this classification of packages at the departure station complicates the make-up of occasional distributing wagons whose destination is a section for which it is exceptional to have a sufficient tonnage.

It should also be remarked that the presence in a train of several wagons containing goods for distribution along the same section, complicates the work at the stations. The result may be frequent and lengthy stops on important lines. In order to remedy this inconvenience (notably when it is desired rapidly to reach the terminus because it is situated in an important locality), only the largest stations E, F and G of the section are served. These afterwards undertake the final distribution by stopping trains, if the scheduled times make

it more suitable, goods destined for *a* and *b* may be sent to F and afterwards be sent back in the opposite direction for distribution. This arrangement has the further advantage of simplifying the work at the departure station since it reduces the number of batches to be prepared.

The tonnage sufficient to justify the allocation of a wagon solely for station G_2 as destination is provided not only by station G_1 but by all the stations of section AB. The arrangements made in such a case would consist of the provision of a *regular pick-up* starting from A, collecting along the journey AB and going thence direct to G_2.

The running of *occasional pick-ups* is impracticable on account of the difficulty of liaison between the stations with the object of combining their loads.

If we now consider the traffic on section AB and that on CD, we are led to anticipate the running of a combined *collector-distributor* train which will pick-up the goods on the first of these sections for distribution in the second section.

The four varieties of wagons which we have described; reserved, collectors, distributors and collector-distributors, enable goods to be transported directly from dispatch to reception station. When this is impracticable, recourse must be had to several transhipments at *central stations* which have suitable distributing facilities.

Supposing that an examination of the traffic at a certain station shews that it provides daily an important number of articles for conveyance to stations situated within the radius of action of a central tranship station. These articles will be loaded in a « group » or « batch » wagon for dispatch to the central station

mentioned, which in turn will make up *reserved* wagons for certain stations and will re-dispatch other articles in *distributor* wagons. Such groupings may be regular or occasional.

If it is a question not only of a single dispatching station but of all the stations in a section, it is then necessary in the first place to utilise *collectors* for removing the articles to the central station whence they are re-distributed.

The methods which we have just examined enable the conveyance of the goods to be achieved with only one transhipment; when these are not practicable, several transhipments must be resorted to. In practice, where important traffic currents are concerned, an effort is made to limit their number to two.

9. Mode of conveyance for express parcels.

The method followed for the transport of express parcels on a system comprises :

1. The determination of appropriate trains.

2. The scheduling of wagons for regular running in these trains with indications of their function, for example — *reserved* for such and such a station — *collector* for such and such a section having as destination a given station.

To these regular wagons must, of course, be added occasional wagons whose use is *obligatory*, whenever they can produce more rapid handling than the scheduled wagons.

Daily and seasonal fluctuations in express traffic cause the regular wagons to be redundant on occasions or inadequate on others. In such cases their withdrawal or duplication is the remedy. When the scheduled wagons are, from the above cause, withdrawn it is then necessary to specify in what alternative vehicles the goods must be conveyed. When the scheduled wagons are duplicated, there arises the necessity of taking certain precautions when a number of batches of goods are to be handled; thus, in order to facilitate distribution at stations it is helpful *to appropriate one of the wagons* for certain batches and the other for the remaining batches.

The necessity for performing shunting operations in an expeditious manner at wayside stations, makes it desirable to decide in advance the order in which the various wagons are to be arranged in the trains. It is, moreover, necessary, in certain cases, whether by reason of the nature of the goods under conveyance, or with the object of ensuring still greater simplification of the shunting, to stipulate the particular variety of rolling stock to be employed. It might be required, for instance, that a certain wagon should be fitted with a hand brake on account of the position occupied by it in the train.

All of the preceding requirements form the subject of instructions which are issued to the various stations for their guidance.

10. Procedure at departure stations.

The loading of packages is carried out in many stations on the passenger platforms. In order that this work may be performed expeditiously whilst the train stands at the station, it is desirable to arrange in advance all the merchandise on trollies which are placed in convenient positions.

In the more important stations, loading takes place at platforms in a special shed or depot. We will say a few words about the organisation of the work in such a depot.

One method consists of making up the maximum number possible of *occasional* loads so as to reduce the number of transhipments to a minimum. With this object in view, the goods are sorted out on the platform, up to as late a time as

possible before loading up. Amongst all the packages thus assembled, are selected those to make up *reserved* wagons, *distributor* wagons and *occasional group* or *batch* wagons *procuring* a more rapid delivery than by the regular scheduled wagons. The latter convey all remaining goods not already allocated to any of the previously mentioned wagons.

This method assumes that :

1. During a sufficiently long period of time there is assembled in the depot a large number of packages for the same direction.

2. It is possible to utilise a sufficiently large area of platform for the sorting of the goods during this period.

The first condition is usually inconsistent with the necessity of despatching without delay the express parcels traffic and of sending it in the same direction by different trains.

On the other hand, the method described is evidently only justified when the traffic is very irregular; if it were otherwise, an intensive study of the traffic would enable scheduled wagons to be judiciously selected, thus making *occasional* loads very infrequent. This is actually what happens at the majority of important despatching centres, but this method is comparatively seldom made use of.

The commonest method is to load the goods as they arrive into the regular wagons which will carry them, but this is not easily applicable to the loading of multiple batches. In order to permit of the correct sorting of these lots or batches, it is worth while arranging them on the ground before making up the loads. This procedure, moreover, is consistent with the fact that it is not usually possible to place at the platform at one time the full number of wagons for which provision is made in the instructions circulated to the staff. In such a case it is more profitable to place at the loading platform those wagons to be loaded with only a small number of lots (e. g. *reserved wagons, group wagons* for a tranship centre), whilst the articles for the other wagons are provisionally placed on the ground.

Irrespective of the method adopted it is essential that the staff should know at once in which wagons goods have to be loaded or in which bay of the shed they should be deposited. It is worth while, with this object in view, to have a permanent staff in the depots, so that it may be instructed in the routine of the shed and in the geography of the system. In order to facilitate the duties of the men, they might well be supplied with notebooks containing a list of the stations of the system and opposite each the numbers of the wagons serving them, or giving the numbers of the bays of the shed where goods should be loaded for various stations. Tables might also be issued to assist the memory of those responsible for loading the « mixed lot » wagons.

When articles are loaded into trains during wayside stops, it is customary on some systems to compile a list stating exactly what goods are put on board. But, on account of the time spent in making up this list, it is a more common practice to hand to the guard a list along with the goods, and it is the guard's duty afterwards to verify the list.

In the case of the handing over of certain articles of value, however, mutual checking by the two parties is required and a signature must be given.

11. Transmission of documents.

On some systems, the documents are forwarded by the quickest routes independently of the goods to which they refer. The handling of the latter depends in such cases on inspection of the labels. But it often happens that the quickest means of transmission is by the train conveying the goods. Moreover, the documents are extremely help-

ful to the guards of stopping trains in enabling them to prepare the goods for unloading. The majority of railway companies insist that goods should be accompanied by their relative papers. The station at which a wagon load of mixed goods is prepared issues to the guard all the waybills concerned. If a wagon connecting two stations only is concerned, all the papers are frequently placed in the sealed wagon for the sake of security. The head guard keeps by him the bundles or envelopes of the goods he handles. He is responsible for assembling all papers referring to goods collected and for preparing waybills for goods to be distributed at the various stations, these being handed over along with the goods.

12. Duties « en route ». Train staff.

The train staff is held responsible for the conveyance of goods in trains under their charge.

The head guard sees to it that the packages are correctly loaded into the wagons; he distributes his men suitably among the wagons to be unloaded so that the packages are ready in advance and that the handling is performed in a minimum of time.

For express goods trains on lines where the traffic is heavy, specially trained men should be used, so that they may be thoroughly acquainted with the composition of their train, the detailing of wagons and the traffic at the stations; under these conditions they work quickly and efficiently. By reason of the great importance of this matter, some companies have given especial attention to the selection of suitable staff. For example, the Dutch Railways, where the train staff must pass an examination in the geography of the system, the system of express goods transport, the stowage of goods, etc. A bonus is awarded to those who do well at this examination.

In order to facilitate the sorting of goods by train personnel with the object of reducing standing time at stations, various systems have been devised. For instance, certain companies, the French Paris - Lyons - Mediterranean amongst others, have constructed special stock, the wagons being fitted with communicating gangways.

Other companies, having the same object in view, use bags, baskets or boxes for the reception of small articles or for the protection of fragile or valuable loads. Answers received, however, indicate that this practice is not widely spread; the principal obstacle to their use appears to be the difficulty of returning these containers, when empty to the big despatching centres where they are required.

It may be noted that the French « Est » Railways have devised a method of discharging fish traffic in a very rapid manner at stations en route; we will return a little later to this question.

13. Transhipment.

We will examine here only transhipments at important centres having special equipment; these are not very numerous.

As we indicated when discussing operations at departure stations, two distinct methods present themselves.

The first would consist of unloading at the depot all the packages and arranging them so as to give the greatest number possible of *occasional* wagons. This method is scarcely ever followed in practice, for reasons already given, and above all on account of the short period which exists between the arrival of a package and its departure by a specified train.

Wagon-to-wagon transhipment is therefore looked upon as being the ideal system.

Amongst the wagons which arrive at a tranship centre some terminate there, others merely make a halt to leave some

lots and take others on board. All these vehicles are passed through the sheds in the order prescribed by local factors which comprise the sequence of the trains as much in arriving as in departing. The goods are unloaded and transferred at once to the wagon which is to carry them further, whenever this wagon can be placed at the loading platform.

Wagons having the station as terminating point, are generally made use of *after partial unloading*. An important question which now arises is that of the rational re-use of the wagons. This is attained, in practice, thanks to the experience of the staff, who are thoroughly acquainted with the direction of flow of traffic and the approximate amount of the batches brought in by the different wagons; a consultation of the documents when these accompany the merchandise, permits them to make a decision whilst having full knowledge of the facts appertaining to the matter.

Thanks to the procedure which we have just described an economical use of the tranship shed is accomplished by not stacking more than a small quantity of goods on the platforms, the bulk of the goods being taken directly out of one wagon and put into another. It follows from this that in order to minimise handling, the width of the platforms should be small, but on the other hand, their combined lengths should be great, calculated according to the number of wagons which must stand simultaneously at the platforms.

It may happen that it is required to transfer goods from one train to another whilst both trains are in the station at the same time. It is then convenient to bring these trains without uncoupling or shunting alongside either side of an unloading platform, whence they would depart on the conclusion of the transference of the goods.

As an example of such an arrangement we will refer to the station of Rognac (French P. L. M.). The odd number tranship platform which is shewn on the diagram is 250 m. (820 feet) long and 7 m. (22 feet) wide. It is flanked by two roads which stretch along its entire length and to which access is gained from the principal odd-number road by means of two-throw switches. Freight trains are received directly into these roads and their contents are in part removed from wagon to wagon. The timetables of the freight trains are drawn up in such a manner as to limit the maximum duration of the stay of transhipped goods to 4 hours.

The location of the tranship platforms should be determined with the greatest care. Connection between the platform roads and the principal roads should be obtainable in a rapid and easy manner, either by means of points, or transporters, or simultaneously by both methods.

The activities of a tranship shed, being dependent on the times of arrival and departure of connecting trains, vary considerably in intensity during the course of the day. The strength of the attendant personnel must vary accordingly.

This personnel is organised in gangs each comprising an identifier and a certain number of porters. The number of porters in a gang is determined according to the local requirements; it may vary with the type of wagons to be unloaded or loaded.

On account of the large number of articles which may be contained in a single wagon, it is only practicable to ensure correct identification of them by means of documents, and in addition the tranship work is effected by reference to these documents. The identifier, on handing over a package to a porter, informs him in which wagon it must be loaded or in which bay of the shed he must dump it.

Likewise, when the articles temporarily dumped on the ground are to be reloaded, the identifier points out to the porters the wagons in which the goods are to be placed. If they have to be

sorted into several batches in the wagon, it is necessary to employ a man specially for the duty of preliminary sorting and classification of the goods as they are brought up by the barrow men. If it is in particular a question of wagons which must leave the depot after a very short halt, in order to ensure delivery on a nearby section of line, it is sometimes convenient to engage the services of the guards of the train which will take them away, for this duty of sorting; the work of these men will be subsequently facilitated on the journey.

On some systems (North of Spain Railways), the permanent staff in the tranship sheds is restricted to a few foremen, whilst all the handling work is performed by the crews of the trains which haul the wagons. However, in the majority of cases it is the station staffs who are responsible for these duties. The duties of barrow men can quite well be carried out by men having no special skill; temporary hands, or labourers furnished by a contractor serve the purpose. On the other hand too much care cannot be devoted to the selection and organisation of the men entrusted with identification duties.

CHAPTER III.

Organisation of the carriage of slow parcels traffic.

Summary.

a) General organisation.
b) Operations at the departure stations.
c) Working of the tranship centres.
d) Procedure at the arrival stations.
Resume concerning the carriage of slow parcels traffic.

a) General organisation.

1. *Regular wagons.*

A consignment of small goods cannot, as a rule, go from its departure to its arrival station in the same wagon without transhipment; it is in consequence impossible to allow it to be loaded into any wagon which happens to be convenient, but it must be put into a designated wagon with a definitely planned journey before it. This scheme for the conveyance of small consignments, should, in order to ensure a sufficiently expeditious handling, be planned so as to offer daily to any station the means of providing transport to any other station on the system (or to any connecting points with neighbouring systems), for a consignment of goods, even of small bulk or importance, and to ensure daily connections at stations not served directly by trains from the originating station.

In fact, all the companies have an organisation of *regular wagons* for the conveyance of small consignments, i. e. wagons running *daily* according to a timetable and under no conditions as to tonnage. These *regular* wagons, the numbers of which vary according to the importance of the system, have a clearly defined use and purpose, which are roughly the same for all localities, namely : *collectors* which pick up goods en route at successive stations to convey them to a common point of destination or transhipment : *distributors* filled at a given point with goods for discharge en route at successive stations; *collector-distributors* which pick up en route at several successive stations, goods having several other stations as destinations to which they are to be distributed; *reserved wagons*, loaded at one station with goods having a single and common destination; or *group (batch)* wagons destined for a given point, loaded for a number of stations with goods for transhipment at this point thence re-consigned to their ultimate destination. These diverse categories of wagons have different designations on different systems; thus collectors, distributors and collector-distributors are on some systems called « wagons de course »; complete wagons are called « wagons de gare »

(« station wagons »), and the « group » or « batch » wagons : « wagons de zone » (« zone wagons ») or « wagons de parcours » (« trip wagons » or « tranship wagons »).

For convenience of language, we shall use in this report, for each category of wagon defined above, the designation *in italics*.

But what is the method which is responsible for the establishment of these organisations ? On what foundations do they rest ? From a perusal of the replies which have been made to our questionnaire, the doctrine followed in certain cases appears rather indefinite and the corresponding regimes rather empirical; several companies have however explained the principles of their organisation in a most complete manner; these principles are rather diversified. Certainly the problems involved are complex and the quest for its solution, which is in short that of the rapid transport of goods, depends on different factors which are sometimes contradictory. The companies must in particular take into account :

— the number of transhipments which the goods must undergo in course of transit, with the attendant risk of damage;

— the lengthening of the period under transit, and the ensuing costs of handling;

— the number of wagons to be allocated to this service and their economic utilisation : if, for exemple, it is desired to reduce the number of transhipments, one is led to employ on occasions « through » wagons which are only partly filled;

— the costs of haulage and shunting, which vary with the rolling stock employed : if, as has been stated, in order to speed up working and reduce the number of transhipments, it is decided to use lightly loaded wagons, one increases thereby the number of such wagons in service, thus appreciably increasing costs of haulage and shunting, etc., etc. To which of these factors is it desirable to give preference, and to what extent ? Opinions are divided.

However, it may be said that the various regimes of organisation of ordinary parcels transport suggest the following classifications, which we will call A, B, C and D. One commences as a rule with the organisation of slow stopping trains, which serve, one in each direction, the same stretch of line; each of these stretches of line is called a « section ». The system is thus divided into a certain number of sections, say « N ». Incidentally certain important stations in themselves constitute a section.

Regime A. — It is easy to realise the sending of a package from any station whatever to any other station wathever.

Each section if served by (N-1) *regular* collector-distributor wagons. Each of these collects the goods destined for one of the other sections and travels as part of the appropriate train, having regard to the direction in which the destination section lies. After having completed its stopping trip on the pick-up section, each wagon is hauled by a direct train to one of the starting stations of the destination section, along which it does its distributing whilst forming part of one of this section's two stopping trains.

On each pick-up section, for the conveyance of the goods which the stations of this section send to one another, one ought, in theory, to add to the stopping train in each direction, one collector-distributor wagon called « route wagon » specially detailed for this purpose, which would necessitate a supplementary 2N wagons. But the (N-1) wagons serving the section in the conditions above indicated are evidently not all well loaded, and it is always possible to find at least two capable of performing

this « route service » : thus no special provision need be made.

To sum up, this regime requires each day, as *regular wagons*, the putting into commission of (N-1) collector-distributors for each despatching section, making a total of N (N-1) wagons.

The two slow stopping trains (one in each direction) of each section have to haul between them not only the (N-1) wagons collecting along the section for the other sections, but in addition the (N-1) wagons coming from the latter and containing the goods sent from them. Thus the two stopping trains of each section comprise together 2 (N-1) *regular* wagons.

Regime B. — One can aim at ensuring the conveyance of an article from any one point to any other point whilst stipulating no more than one transhipment, after which it is conveyed to its destination in a distributing wagon.

Where will this single transhipment take place ? If the system is not very extensive, one can imagine that it would comprise only a single transhipment centre C in an approximately central position, functioning both as a reception and distribution centre. Each of the N sections then sends a « collector » to C, whilst C in turn provides a « distributor » for each section.

But it is evidently indispensable, as soon as a system reaches a certain magnitude, that there should be several

Fig. 1.

tranship centres. Supposing (see fig. 1) that on a given system there are p tranship centres, C^1, C^2..., C^p. Each centre is responsible for a certain zone of distribution, comprising n sections : n^1 sections for the zone attached to C^1; n^2 for the zone attached to C^2, etc... and eventually n^p sections for the zone attached to C^p, Σ n being equal to the number N of sections in the system.

Each of these N sections is served by p collectors, each having as rallying point, one of the tranship centres. Each of the latter creates n distributors, there being 1 for each destination section; centre C^1 creates n^1 distributors, centre C^2 creates n^2 distributors and so on.

Supposing that station X sends a consignment of small goods to station Y, comprised in the distribution zone of centre C^4 : X, among the p collectors which serve it, loads the consignment in the wagon which has C^4 as rallying point. The terminus station of the stopping train which serves X and in which travels the said collector, sends the latter by direct trains to C^4. This centre tranships the goods and loads them into the distributor serving the section in which Y is situated.

Such a regime necessitates the employment daily of Np collectors + (n^1 + n^2 + ... n^p) distributors, that is to say, as Σ n = N, Np + N (p + 1) regular wagons, without any provision being made for « route » wagons because the p collectors engaged on a section are not evidently all fully loaded, and one at least is always found to be available for this « de route » service. The only occasions on which this number of N (p + 1) regular wagons may be exceeded is when it is found advantageous to serve a single section by two distributors, one of which emanates from the normal centre supplying the section and the other from a second centre. This is the case when a section, dependent upon C^1 for example, occupies entirely the distance between C^4 and C^1 and when each of these centres

despatches a stopping train travelling from one end to the other of the section. Sometimes it is worth while, in order to gain speed, for the goods emanating from the right of C^4, not to be sent to C^1 but to C^4, and for provision to be made for the service on the said section by a distributor from C^4 as well as from C^1. To sum up, the daily strength of regular wagons to be put into commission may vary from N $(p + 1)$ to N $(p + 1)$ + N = N $(p + 2)$ as a maximum.

The two stopping trains of each section must haul between them the p collectors, the distributor and eventually a supplementary distributor, as has been explained, say a maximum of $(p + 1)$ to $(p + 4)$ *regular* wagons.

Regime C. — Conveyance with a maximum of only one transhipment may also be achieved in the following manner :

Each of the p tranship centres, e. i. C^1, C^2..., C^p, has dependent upon it a certain pick-up zone, comprising n sections; each of these zones is visited by a collector which terminates at its collecting centre : n^1 sections therefore send their goods, without exception, to C^1; n^2 sections to C^2, etc... and n^p sections to CP, Σ n being equal to N. Each of these centres then makes up N distributors serving each one of the sections of the system.

A similar computation to that already made for regime B shews that regime C necessitates the employment daily of $(n^1 + n^2 + ... n^p)$ collectors + Np distributors = N $(p + 1)$ regular wagons. For reasons similar to those which in regime B led to the use on certain sections of an additional distributor, it follows that one can serve such and such a section by a supplementary collector working towards a centre other than that to which it is normally attached. The daily strength of the regular wagons to be put into use may consequently vary from N $(p + 1)$ to N $(p + 2)$ as a maximum.

Similary, the two stopping trains of each section have to haul between them from $(p + 1)$ to $(p + 4)$ regular wagons as a maximum.

Regime D. — One can finally imagine that the conveyance of parcels is realisable, in principle, with a maximum of two transhipments for each consignment, in the following manner : the goods are despatched to a tranship « collecting » centre, situated in close proximity to the originating station : after transhipment this centre then sends the articles in a batch to a tranship « distributing » centre situated in close proximity to the destination station. The latter centre finally put the goods on board a distributor wagon for its ultimate destination. In fact, each centre serves at one time the double purpose of a « collecting » and « distributing » centre for the stations of the zone surrounding it.

Let again N be the number of sections in the system and p the number of tranship centres. Each section is served by a collector for each direction, going respectively to one or other of the two pick-up centres the nearest to the ends of the section, that is to say, for the whole system by 2 N collectors. The direct « group » (or « batch ») wagons which connect two by two the tranship centres are numerically equal to p $(p - 1)$. Finally each centre is served by a distributor in each direction, coming respectively from the two distribution centres which are the nearest to the section, that is to say, for the whole system, by 2N distributors. On some sections, the collector wagon, or in default, the distributor of each direction may, at the same time as it carries out its normal service, pick-up the goods proceeding from any station whatever of the section to any other station wathever of the same section : if on the contrary the size of the traffic of the collectors and distributors does not permit of this, it is necessary to add on each section in each

direction, a « collector-distributor » called a « route wagon », making 2N wagons of the kind. The number of regular wagons to be operated daily with this regime is thus between : 2 N collectors $+ p (p - 1)$ « batch » connectors $+ 2$ N distributors $= 4 \mathrm{N} + p (p - 1)$ wagons in all, and the same number, increased by 2 N « *route wagons* », making $6 \mathrm{N} + p (p - 1)$ « *regular wagons* » for the whole of the system.

On a given section, the stopping train in each direction comprises, in principle, one collector and one distritor to which may be added one « route wagon », making a total for the two trains of 4 to 6 regular wagons.

The table hereafter sums up the characteristics of each of the regimes just analysed and makes applications to concrete cases assuming on one hand, a small system R^1, comprising about 20 sections and 2 tranship centres, and on the other hand, a system R^2 of considerable extent, comprising, as the French Est Railway, for example (5 000 km. = 3 100 miles of line approximately) : 190 sections and 16 tranship centres. An examination of this tables enables the following conclusions to be drawn.

Regime A. — This regime obviously reduces the handling operations to a minimum and in consequence, the costs resulting therefrom and the risks of damage. But it has the following serious disadvantages :

1. It would require a heavy establishment of wagons. On the small system R^1, the number of wagons to be operated daily would be 380; on system R^2, it would be 35 910 wagons, which is quite a prohibitive figure.

2. Shunting and haulage costs would increase in an inadmissible manner. For instance on system R^1, the two stopping trains (one in each direction) of each section would have to haul between them, 38 regular parcels wagons. Their formation would in consequence be laborious and costly and their haulage likewise. Moreover, in many cases, they could not, with such a quantity of parcels wagons in tow, be able to undertake at the same time the service of fully loaded wagons (such as coal wagons, etc.) and they would require to be duplicated.

As for system R^2, the two stopping trains of each section would have to haul between them 298 wagons, which is without doubt absurd and impossible.

Regimes B and C. — These regimes impose on the goods only one intermediate transhipment at the most. On the small system R^1, they would necessitate daily the employment of 60 to 80 regular wagons, and on system R^2, from 3 230 to 3 420 wagons, a figure flagrantly too great. On the basis of a mean turnround period of 3 or 4 days only — and this is not excessive, for in such an organisation, the bulk of the regular wagons would be « of long range » — such a daily figure represents indeed an establishment of from 9 700 to 13 700 wagons to be detailed for parcels work alone.

These wagons, moreover, would encumber the trains whose formation and uncoupling would occasion shunting and haulage costs of an excessive nature. On system R^2, the two stopping trains of a section, between which would be divided the 17 to 20 regular wagons, would be too heavy, and their shunting in the stations highly inconvenient; their running schedule would be extended with increased expense, even more so, since the station staff would, in order to load or unload a few packages, be put to the necessity of going all along the train whilst looking for and opening the various wagons.

Such expenses would be the more regrettable owing to their being out of proportion with the traffic obtained, for these numerous regular wagons usually carry very few goods — some of them

Regime.	Maximum number of trans-shipments per consignment.	Number of tranship centres in use.	Total number of regular parcels wagons to be worked on the system.			Total number of regular parcels wagons forming part of the two stopping trains in each section.		
			Theoretical.	Concrete case of a system comprising 20 sections.	Concrete case of a system comprising 190 sections.	Theoretical.	Concrete case of a system comprising 20 sections.	Concrete case of a system comprising 190 sections.
A	Nil.	Nil.	N (N—1) wagons.	380 wagons.	35 910 wagons.	2 (N—1) wagons.	38 wagons.	298 wagons.
			Theoretical.	Concrete case of system R¹. (*a*)	Concrete case of system R². (*b*)	Theoretical.	Concrete case of system R¹. (*a*)	Concrete case of system R². (*b*)
B and C	1	*p*	From N $(p+1)$ to N $(p+2)$ wagons.	From 60 to 80 wagons.	From 3 230 to 3 420 wagons.	From $(p+1)$ to $(p+4)$ wagons.	From 3 to 6 wagons.	From 17 to 20 wagons.
D	2	*p*	From 4 N$+p\,(p-1)$ to 6 N$+p\,(p-1)$ wagons.	From 82 to 122 wagons.	From 1 000 to 1 380 wagons.	From 4 to 6 wagons.	From 4 to 6 wagons.	From 4 to 6 wagons.

N denotes the number of sections in the system.
a) System R¹ : System of small extent, comprising 20 sections and 2 tranship centres.
b) System R² : System of considerable extent, such as that of the French Est Railway, having about 5 000 km. (3 100 miles of lines) 190 sections and 16 tranship centres.

would often travel empty — thus being used in a wholly uneconomic manner.

Regime D. — In this regime, the number of regular wagons to be put in operation daily is between 82 and 122 on system R¹, and from 1 000 to 1 380 on system R².

The collectors, the distributors and the « route wagons », the total number of which may vary between 4N and 6N, say, for system R², from 760 to 1 140, make short trips and have a turn-round period of scarcely one day. The $p\ (p-1)$ or $16 \times 15 = 240$ batch wagons connecting between them the tranship centres are of longer range and have a mean turn-round which may be estimated at 3 days. Taking account of these figures it is seen that this organisation requires an establishment of 760 or 1 140 plus $240 \times 3 = 1\,480$ to 1 860, or, in round figures, from 1 500 to 2 000 vehicles to perform the parcels work in regular wagons. In all these cases, on a given section, the stopping train in each direction scarcely comprises in principle more than a collector and a distributor, to which may be added, as mentioned, a « route wagon », making a total of *3 regular* wagons

per stopping train. Under these circumstances the service is not too complicated so far as the working of the trains at stations is concerned.

These various figures are reasonable and can be admitted in practice, especially as, when thus reduced numerically, the *regular* parcels wagons have every chance of being properly used.

Undoubtedly the regime requires, for a certain number of goods, two transhipments, with the inconveniences inseparable from these operations; time lost in the sorting of wagons preparatory to placing them at the platforms and in their withdrawal and corresponding costs for shunting; time lost at the platform itself; handling costs; risks of damage. It is true that it is not impossible to reduce these inconveniences by a carefully drawn-up organisation, notably the multiplication of the withdrawals of wagons loaded from the platforms, and tranship wagons, by the assistance of transport contractors, the improvement of appliances for loading and unloading — all subjects to which we shall return later on.

We are of the opinion, so far as we are concerned, that regime D, which means a maximum of two transhipments per consignment (reduced to one only in many cases and sometimes to none) can, at least for systems of a certain extent, be recommended as realising a fair solution of the problem of the conveyance of parcels traffic. This solution takes adequate account of the essential factors — handling, economic use of the rolling stock, costs of shunting and traction.

But, in practice it is not possible to adhere systematically and absolutely to this regime, nor for that matter to any other. It is necessary, by means of the addition of ideas borrowed from other methods, to modify it for the purpose of adapting it to the traffic requirements of certain lines. Suppose, for example, that a given locality in section X of the system, happens to produce or manufacture every day materials which are treated or consumed either by :

— localities of the same section Y but at a distance from the first;

— or a single and common locality W;

— or again various localities at a considerable distance, not situated on one and the same section, but all nevertheless dependant on the same tranship centre T^1.

Here the solution would be to modify and perfect regime D by putting in operation daily a wagon for picking up the goods in Section X, namely :

— in the first case, a *regular* collector-distributor (characteristic borrowed from regime A), which distributes the goods without intermediate transhipment on section Y;

— in the second case, a *regular* collector which takes them to W, equally without intermediate transhipment;

— in the third case, a *regular* collector terminating directly at T^1, whence the goods are subsequently, as in regime B, conveyed to their destinations by a distributor, after a single transhipment, although they have traversed the entire system.

Still further cases may arise. It happens that the stations of several branches radiating from a common centre T^2 produce or manufacture daily a certain quantity of goods which are treated or consumed either by : localities of a common section some distance afield, or a single and common locality W; it is desirable to arrange for the running from T^2 :

— in the first case of a *regular distributor* of long range for section Y;

— in the second, of a *reserved regular* for W; these goods are thus conveyed with a single transhipment.

Finally, a single locality A can produce daily, for example, cloth which has to be sent for dyeing or preparation :

— either to different localities of a

single distant section Y, — or to a single common locality W, or to localities situated on 2 or 3 branches radiating from a distant centre T³. It is then the plan to arrange for the running daily from A :

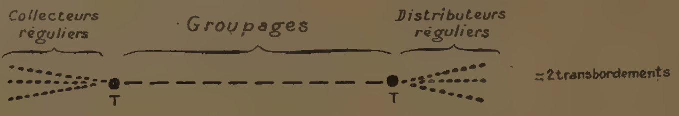
— either of a *regular distributor* for section Y, or of a *regular reserved* for W (the goods are in these two cases carried without any transhipment);

— or of a regular *batch* wagon for centre T³, which forwards them respectively in the distributors of each of the destination branches with a single transhipment.

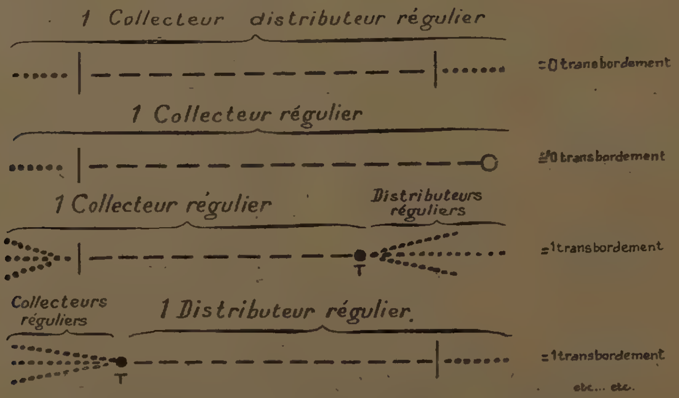
It might be objected that the use of *collector-distributors* or of *distributors* of long range planned in certain of these cases is not without its drawbacks. Indeed, in spite of the precautions taken on loading, for carefully arranging the goods according to destination stations, shocks received on a long journey and in shunting, quickly result in the batches becoming inextricably mixed, which makes the work of distribution during stops at stations very difficult. Although this is true, there are ways of remedying it, either by having a re-sorting of the articles made in the wagon, just before its entry into the distributor section, or by using, in the greatest possible measure containers which permit of separating goods for different destinations and preventing their mixing in course of transport.

If the letter T is used to indicate the transhipments undergone by the goods, and the sign ...... to indicate sections of collection or of distribution by stopping trains, the sign ----- the direct runs, and the sign ○ a given despatching or receiving station, it is seen that one may, by writing above each run the kind of wagon used, lay out diagrammatically in the following manner the transport of parcels by *regular* wagons.

In regime D, such as has been defined in principle :



and in the other cases, dealt with above :



Note : Collecteur = Collector. — Distributeur = Distributor. — Groupages = Batch wagons. — Régulier = Regular. — Transbordement = Transhipment.

To sum up, if an organisation comprising a maximum of two transhipments appears admissible as a common regime, for isolated parcels without any character of regularity between any fairly distant points, it requires to be supplemented by other arrangements each time one is concerned with currents of traffic having a degree of regularity; in order to detect these it is necessary to take a census of the traffic on the various lines of the system. When this analysis reveals sufficiently heavy streams of traffic, but above all regular rather than large streams, of such a nature as those mentioned above, there are grounds to encourage the putting into circulation of *regular* wagons, to ensure rapid handling of freight with the minimum of transhipments.

It is profitable, moreover, to repeat periodically these traffic analyses so as to discover whatever modifications the kind and form of traffic may undergo from time to time, and to introduce corresponding changes into the organisation of the *regular* wagon service.

We will add the following : — it has sometimes been suggested to traders that they should collaborate with the railway, in handing in on Mondays, for example, traffic whose destination is the Lyons region, on Tuesdays traffic for the neighbourhood of Bordeaux, etc..., so as to enable the originating station to make up on those days through and fully loaded wagons for Lyons, Bordeaux, etc. One might make the following remark on this subject : — now that the telephone and telegraph are largely made use of by traders for sending orders, they desire, and quite naturally, to be able to execute them very quickly and not to be obliged to wait for a specified date. This wish is the better understood in these days of economic instability when the merchants restrict their stock to the minimum, and they re-stock normally with small quantities and only to keep pace with the requirements of their customers. It is thus necessary that these goods should be sent to them on demand and immediately by their suppliers. It might well then be asked if the appeal made to the public can be expected to be successful; however that may be, the measure, interesting in principle, can be put into practice ready to be withdrawn at the end of a certain period of time on those sectors where it does not give satisfactory results.

2. *Conditional wagons.*

The carriage of parcels by *regular* wagons is not always the quickest form of transport, particularly when it necessitates one or two intermediate transhipments. Moreover, on the majority of systems, every station has the authority — and even the obligation — when it possesses, amongst the goods which, having regard to their common destination, ought normally to be loaded into the same regular wagon, a batch of goods of a sufficient weight or bulk, to constitute along with the others a through or semi-through wagon which is, in a way of speaking, an offshoot of this regular wagon. These wagons are termed « supplementaries » or « occasionals » or « conditionals » (on account of the condition imposed upon their employment). The requisite weight for this purpose varies with different companies; it usually goes from 1 000 kgr. to 2 000 kgr. (2 200 to 4 400 lb.). It reaches even 2 500 kgr. (5 500 lb.) on the Andalusian Railways, 3 000 kgr. (6 600 lb.) on the Swedish and Norwegian Railways and 4 000 kgr. (8 800 lb.) on the Finnish State Railways.

The various categories of *conditional* wagons used on the systems are, notably :

— the « *batch* » *conditional,* containing goods destined for a variety of stations all situated within the neighbourhood of an important centre, which plays the part of « distribution centre » with regard to them. Instructions give the terminating point of these « *batch* » *conditionals* and give a list of destination stations comprised in the zone of each

one. Articles loaded in a *batch conditional* are carried direct to the *distribution centre* instead of simply being taken, as they would have been in a *regular collector*, to a preliminary so-called *pick-up centre*. In this way one transhipment out of two is avoided. Sometimes the terminating point of a *batch conditional* is a point of transit : the wagon is then termed *batch conditional of transit*, and is composed of articles destined for a neighbouring system or its hinterland and intended to proceed beyond the said point of transit. To these consignments are sometimes added articles destined for the distribution zone served by this point of transit, but situated on the originating system.

The *reserved conditional* carries goods the objective of which is a common station belonging either to the home railway or to a foreign one and gets them there without any transhipment whatever.

These wagons are not subject to any pre-determined running schedules, but they travel by the most direct trains in the role of fully loaded wagons. Their use, as we have just seen, obviates the one or two transhipments which carriage by a *regular* wagon usually exacts. The loading of *conditional* wagons thus very appreciably expedites transport, reduces the costs (shunting, handling, etc.) inherent to transhipments, and diminishes to a like extent risks of damage. But it may be asked whether the tonnage [3 000 kgr. (6 600 lb.) and even 4 000 kgr. (8 800 lb.)] required by certain companies for the provision of a *conditional* wagon is not too great, and prevents them in practice from procuring a maximum profit from these advantages, because it is seldom that a single station can get together in any one day such a weight for a common destination, or even for a tranship centre. It would appear, from this aspect, to be worth while reducing to 2 000 kgr. (4 400 lb.) at most the tonnage required.

It happens, moreover, at times, as we shall explain subsequently in the paragraph headed : « Period for despachting the goods », the conveyance by *conditional* wagon may not be advantageous, but may even be the cause of delay in carriage. Such is the case when, not profiting by the facilities afforded it, the station defers the despatch of the goods with precisely the object of gathering together enough tonnage to form a *conditional* wagon; or alternatively, when the tonnage being adequate, the station cannot for some reason or other, load and despatch the goods within a short interval of time. But it is not impossible, as we shall see, to avoid errors by supervising and controlling very closely all procedure at stations. Thus we will conclude, with these reservations, that it appears desirable to perfect the general organisation of *regular* wagons for the transport of parcels by slow trains, but to impose the obligation upon stations to make up *conditional* wagons according to carefully drawn-up rules.

The organisation adopted for the transport of parcels both by *regular* and by *conditional* wagons usually forms the subject on each system of a booklet or special instruction. From the point of view of the operating staff, this instruction conveniently takes the form of a table of the following kind, of which each despatching station ought to possess a copy.

Destination station. (1)	Regular wagon. (2)	Conditional batch wagon. (3)

Column (1), printed in advance, gives an alphabetical list of all the stations on the system (including transit points), all considered as destination stations. In respect to each of the above, the departure station must enter by hand, once for all, the following information according to the general instructions sent to it;

— in column (2) the indication of the

regular wagon in which it is sending a consignment for this destination (or for the outgoing transit point in the case of goods leaving the system), when it does not make up either alone or with other consignments the tonnage required for the formation of a *conditional* wagon.

— in column (3), the indication of the *batch conditional* in which the consignment is to be loaded, if the conditions are met for making up such a wagon.

For the provision of *reserved conditionals* the men have no special instructions to receive; they are responsible, when they have sufficient weight for a single destination, for making up a *reserved conditional* for this destination.

3. *Trains available for the service of ordinary parcels.*

The majority of companies consulted state that the above service is maintained, on the one hand, by means of stopping trains serving sections, and on the other hand, by means of through trains which on the trunk lines, haul rapidly over long journeys, through wagons containing parcels.

Quite usually, the sectional service is made by means of one train in each direction, which performs the dual duty of parcels and *reserved* wagons haulage in addition to the shunting at wayside stations. In some particular instances, however, a train is provided specially for the parcels service and another for that of the *reserved* wagons. When a line is served only by a single stopping train in each direction, these run as a rule during the daytime. They often set off early and arrive late at their terminus. As pointed out by the Swiss Federal Railways, « this regime has the objection of » long stops at intermediate stations and » gives an irrational utilisation of men » and vehicles. But it relieves us of the » necessity of putting into traffic trains » specially for *reserved* wagons of the » small stations — trains which would be » uneconomically employed ». Especially from the point of view of parcels consignments this regime presents a capital disavantage : the handing in of packages by the public occupies the whole of the hours of opening of the acceptance depots, but actually the busiest time occurs towards the end of this period, say between 3 and 6 p. m. The result is that in all those stations where the one daily train has passed during the early day, that is, say before 2 or 3 p. m. that the parcels, and it may be said the bulk of them, have their departure put off by 24 hours. This initial delay is a very regrettable thing for traffic, which one desires, on the contrary, to accelerate.

It would be desirable that the departure of goods from the outgoing station should take place not at any given time during the day but in the evening after the closing of the stations to the public in such a way as to include all the goods handed in during the day. In order to do this, it would be necessary to run in each direction a second special semi-fast train, in addition to the first train for the complete wagon loads, which would take a long time to accomplish its journey on account of station shunting. The second train, passing through stations after closing time (5 or 6 p. m.) would pick up the consignments. The latter arriving at the nearest tranship centre towards the end of the evening, would be transferred, if no hitch occurred, during the night and could continue their journey on the following morning. Since delays are counted by days and since delivery of the goods takes place in the daytime, the railway has every interest in taking advantage of the first night by causing the goods to cover as much mileage as possible during that night, rather than leaving them, as is done today, immobilised at the originating station. Without doubt such an arrangement would cause additional haulage expenses (from which must be deducted savings resulting from economies in men and vehicles by virtue of

the shorter trains), but these costs would be fully justified by the improvements brought about in the parcels service.

Regarding this subject, and although Germany does not figure among the countries covered by this report, we will draw attention to a system put into use some time ago by the German Railways, a system which we saw in operation in the Cologne district; we refer to the light trains for parcels traffic, known as « Leichtegüterzüge » or, abbreviated, « Leig ». These trains meet the requirements mentioned above. In addition to the pair of pick up trains setting off in the evening (one in each direction) the German Railways add a pair of distributing trains on each line, starting in the morning. The following are the most interesting features of this system :

— the composition of the train is reduced to one very large or two very large vans connected by a corridor, forming a kind of station or travelling depot, staffed by an operating squad. The staff loads and unloads the goods at the stations, with the assistance of the local staffs, although the latter may be reduced in number; during the journey the squad sorts the packages, not only with a view to their distribution among the wayside stations, but also with a view to the continuance of their journey beyond the terminus of the « Leig ».

— the handling work is made particularly easy and the running of the trains accelerated by the fact that the system is completed by: — the intensive use of numerous portable hand-operated hoists, and of trays used as containers both in the travelling depot and at the stations; and, in the stations, the use of loading gangways of various forms, spanning as necessary a siding truck, a footway, or even at times, a running line, and which connect the goods shed with the travelling depot when the latter cannot gain access to the road in the shed.

The train, guided by specially placed marks, stops at a clearly defined point; the gangway is rapidly placed in position, whilst in the corridor wagon are prepared on one or two elevator barrows, the trays containing the parcels for the station; the squad trundles them into the shed and dumps the trays, collects other trays got ready by the station and containing its outgoing parcels, then wheels them into the van; the gangway is lifted and the train resumes its journey.

The number of parcels wagons is notably reduced, which procures haulage and shunting economies and, by setting free an appreciable number of vehicles, enables the cost of the wagon establishment to be reduced.

The Reichsbahn, which at first formed its « Leig » trains with big coupled wagons from its stock and hauled them by means of steam engines, now composes them of a single very large Diesel motor van, which is specially constructed for the purpose. It is expected by this manner appreciably to reduce the costs of traction and of footplate staff.

Our colleague whose report covers Germany will certainly not omit to give full particulars of this organisation; but on the understanding that we are here specially examining measures for the purpose of speeding up the transport of parcels, we considered it was not possible to avoid mention of the « Leig » organisation, which appears to us, to realise progress of great interest in the solution of this problem. Up to the present, those companies which we have consulted have not yet made a trial of the « Leig » system; a certain number of them (Norway, Holland, French Est Railway) have, however, studied the matter. As for the Swiss Federal Railways, they state that the investigations which they have made into the questions have given negative results.

On the trunk lines, where a large number of trains are provided, it would seem, a priori, easier, taking into account the number of parcels wagons necessary, to allot to them their own train, exclusive of reserved wagons. Few companies do this, however, probably because by thus allocating such a train, risk is incurred in certain cases, of depriving this traffic

of important opportunities for despatch which other trains procure during the day at various intervals, and also because of the difficulty that exists on a long artery, of arranging that this special parcels train should visit successively at the best time the many big stations and tranship centres which lie on its route : by best time we mean the conclusion of the loading of parcels, after which it is desirable to despatch the wagon with a minimum of delay. This difficulty is caused by the fact that the busy hours of local stations and tranship centres are not often coincident, and also because the train, spending some time on its journey, could not arrive at each place at the best possible time.

Arrangement of « slow parcels » wagons in the trains.

This constitutes a very interesting problem. Are the wagons arranged specially in the trains? Is there anything to gain by doing this?

In the stopping trains, most companies arrange the wagons according to local convenience, either at the front or at the rear, so as, it is said, to facilitate shunting and handling the goods at intermediate stations, by making these operations independent of each other. For through trains, opinions are divided : some make the parcels wagons share the lot of the reserved wagons by mixing both kinds; others, on the contrary arrange them either in the front or in the rear portion of the trains.

We think that such an arrangement is advantageous. No doubt in the stopping trains, the advantage obtained as regards shunting and handling is not equal everywhere. It presupposes indeed that in the small stations there is a sufficient strength of personnel to be divided into two gangs; the first one occupied with the shunting, and the other meanwhile with the handling of the parcels in the vans, which, thanks to their arrangement in the train, do not require to be shunted. But this number of men is not always available, especially since reductions in staff have been made from motives of economy. Moreover, when the wagons are placed at the rear of the train, and this part of it is placed clear of the points the use of which is necessary for the shunting, the parcels handling becomes very awkward, since in the case of long trains, it must be performed away from the platform. In order to avoid this trouble, it is often necessary to move the train forward when the shunting is over, but then the intended advantage disappears.

It is, in our opinion, due to an entirely different aspect, that the special arrangement of parcels wagons is important as much for stopping trains as for through trains. It enables gravity shunting of these wagons at the sidings to be avoided. Their group is put on one side, if required, by the engine of its own train and may be either taken at once to the sorting sidings, where it is placed in the front of the connecting trains; or, if wanted at the tranship shed, they are taken there without delay. A double objective is thereby obtained; reduced risks of damage to parcels, which by their very nature often comprise fragile objects, and their journey is accelerated.

Another measure appears to us to be equally worthy of mention; it is due to the Dutch Railways : « The transport of wagon loads made up of parcels, is placed before that of all other kinds of merchandise. » In other words, *priority* over other vehicles must be given to parcels wagons, except of course, cattle trucks or those containing perishable foodstuffs. If, whilst making up a train, the station finds it has more vehicles than it may incorporate in the train, and it is necessary to leave behind a certain number of wagons, interest commands to refrain from detaching parcels wagons; the vehicles left behind should consist firstly of empty wagons, then

complete wagon loads of various kinds of goods, such as coal, etc...

* * *

We recalled at the beginning of this chapter, that the problem of the general organisation to be adopted for parcels traffic is conditioned by a variety of factors : namely, the speed of this transport, handling, the utilisation of the rolling stock, the costs of haulage and shunting; and we asked the question : « To which of these factors is it desirable to give preference ? »

It is appropriate firstly to note that the speed of transport has not always been looked upon as the prime factor in the problem, or rather as the solution to be obtained before everything else. There are companies which do not believe, for instance, in sacrificing sufficiently the utilisation of rolling stock to rapidity of transport.

Notwithstanding, as stated very justly by the Finnish State Railways in their reply : « Before the competition of road transport, the utilisation of rolling stock was the preponderating factor in this organisation; today it is the speed of conveyance ». This is absolutely our own opinion : the aspect of the problem has been altered.

As to the other factors, our investigations shew that preponderance cannot be given in a definite manner to any of them.

We saw at first that *the principle* of the organisation applied on a system can and ought to be modified, on certain lines, so as to be adapted to the kind, to the magnitude and to the trend of their traffic.

It might be equally good policy to change or amend, from time to time and according to circumstances, the organisation selected. If, for example, labour becomes scarce and expensive, one may be led :

— to reduce the costs of handling by having recourse to contracting firms;

— or to reduce the amount of handling work, for example, by providing additional *regular* through wagons, or by lowering from 1 500 to 1 000 kgr. (3 300 to 2 200 lb.) the minimum tonnage for the formation of *conditional* through wagons, which eases the work of the tranship centres and can only have the effect of speeding up the carriage of goods.

This lowering of the minimum tonnage seems equally desirable in the case of a surplus of stock. It is better, rather than keeping the wagons immobilised, to use them to produce a more rapid conveyance of parcels, and thereby give less opportunity for competition.

Extreme shortage of rolling stock leads sometimes to the quest for a better utilisation of the wagons. It may be possible, in such a case, to reduce the number of *regular* wagons, for example, in combining wherever possible, *collector* wagons and *route* wagons, thereby ensuring by the use of the same wagon both the pick up and batch service to a tranship centre, and the station to station service along the journey. If this regime is applied, for example, on 80 sections, an economy of 160 wagons is realised daily, resulting from one wagon less in each direction.

One may also, with the same object, raise the necessary tonnage for the constitution of *conditional* wagons, by increasing it from 1 500 to 2 000 or 2 500 kgr. so as to reduce their number, and transfer a greater proportion of the traffic to *regular* wagons.

If, finally, a period of unusually high fuel costs is being passed through, it would seem worth while to endeavour to reduce the *train-miles* worked and the *wagon-miles* either by temporarily suspending special parcels trains when such exist and by transferring this service to trains appropriated to fully loaded vehicles, or by reducing the number of parcels wagons in circulation by one of the means indicated in the preceding paragraph.

The essential thing is, whatever may be the nature and extent of the measures which one may be led to introduce, to watch carefully that they may have only a minimum influence on the *speed of transport*, which it is desirable to maintain before everything else.

b) Operations at departure stations.

1. *Handing-in period.*

It has been pointed out above, that in the case of nearly all Companies, stations are generally served, from the point of view of slow parcels traffic, once daily in each direction by *regular* wagons.

For the sake of simplicity of terminology, we will designate by *handing-in period*, for a regular wagon, the time which separates its arrival at — or departure from — a station on one day to that on the next day; it is the period of time during which the public hands in articles for destinations to be served by this *regular* wagon. In those stations, of sufficient size to be served by night shunting, the *handing-in period* coincides purely and simply with the period during which the station is open to the public. In small and medium-sized stations, which are usually served during the day by local stopping trains, the *handing-in period* for each of the *regular* wagons visiting it, extends into two days. If, for example, a *regular* wagon arrives at or departs from the station at 3.0 p. m. its *handing-in period* goes on the one hand from 3.0 p. m. to the time of closing the station to the public (5.0 p. m. or 6.0 p. m.); and on the other hand, on the next day, from the time of opening the station to the public (7.0 a. m. or 8.0 a. m.) to 3.0 p. m.

2. *Period for despatching goods.*

Most Companies prescribe that a station should despatch, in principle, each consignment by *the very first regular wagon* corresponding to its destination, which serves the station, after its reception, unless the necessary conditions are fulfilled for the formation of a *conditional* wagon.

But would it not be desirable to authorise stations to defer parcels under certain circumstances, namely, with the object of endeavouring to obtain enough of them to justify the formation of *conditional* wagons by bulking the articles received during two or three consecutive handing-in periods? Several administrations do this (French Nord, North of Spain Railway, Madrid-Saragossa-Alicante), judging that the conveyance by through trains of the wagons thus constituted more than compensates for the initial delay imposed upon the merchandise.

On the contrary, the majority of the other railways do not allow this, since they consider that any latitude permitted in this direction to the stations runs the risk of degenerating into abuse : indeed, it is the small and medium sized stations, visited by local trains which voluntarily endeavour, in order to ease the work on the platforms, to dispense with the transfer of the articles from the shed to the stopping point of the train. They have thus the tendency, as experience shews, to retain the goods much beyond the authorised period : such extensions of their stay in the shed can only result in delay, miscarriages and risks of damage or of pilfering. To these drawbacks be added the following : it is by no means certain, allowing for variations in the quantity of articles brought by the public, that even at the price of a waiting of several days, sufficient goods will be accumulated to justify the formation of a *conditional* wagon. In this case, either a conditional wagon is constituted willy nilly and it travels with a poor load, or the tonnage collected is so small that the station judges it quite unjustifiable to make it the object of a *conditional* wagon, and resolves, finally, to load it into the regular wagon, and then the initial delay undergone by the goods is only augmented.

The least that can be said is that the exercice of such latitude is very difficult to control; also it seems preferable, if it is thought worth while in certain cases to deviate from the rule of immediate despatch, to allow it only in stations within closely determined limits in such a way as to make supervision possible.

But we will go further; it may happen when a station, in the course of a single handing-in period, has gathered together the requisite tonnage for the formation of a *conditional* wagon :

— either that the necessary vehicle is not forthcoming at the station or that it cannot be supplied from elsewhere. The case is frequent enough during times of scarcity of rolling stock, even although priority must be given to supplies wanted for parcels traffic;

— or, although being in possession of the vehicle, yet the station cannot manage to load it or to prepare it for departure quickly enough, possibly on account of shortage of labour or of difficulties connected with shunting.

We are of the opinion that there should be no hesitation in such a case in prescribing that, if the *occasional* wagon cannot, *for any reason whatever*, be properly *loaded* and *forwarded* at the latest by the evening of the day following the receipt of the goods, its formation should be abandoned and the goods should on that day be loaded into the regular wagon of appropriate destination. Otherwise, whilst waiting still longer to constitute the *occasional* wagon, there would be lost, at least in part, the advantages which this mode of conveyance has precisely the object of procuring, and the goods would, on the contrary, be delayed.

3° *Preparation of the programme for the handling of parcels.*

The speed of transport of a parcels' consignment depends principally :

1. On the celerity with which it is got under way. We saw previously that this is obtained by the loading of the goods either in the first *regular* wagon of appropriate destination visiting the station after their receipt, or, when justified, in a *conditional* wagon despatched as early as possible after the handing-in of the goods.

2. On the correctness of its loading, we mean to say that, if the consignment does not justify, either alone or in conjunction with others, the formation of a *conditional* wagon and if it ought, in consequence, to be loaded in a *regular* wagon, chosen according to the instructions having regard to its destination, it is absolutely essential that it should be loaded in this *regular* wagon and not in any other. Indeed, in the latter case it would run the risk of straying and would be submitted to a greater number of transhipment as prescribed by the general organisation in force, and in consequence it would be delayed. If, on the contrary, the consignment fulfils — if needed with others — the conditions necessary for the formation of a *conditional* wagon, it is important that the station should not fail to take advantage of this fact and to constitute the said conditional wagon, and therein suitably load the goods. In default of this, the consignment, if put into a regular wagon would not benefit from the speed of transit which the conditional wagon would have procured for it.

To determine correctly in which wagon each consignment should be loaded means nothing more nor less than to draw up, for each handing-in period, a programme detailing how each consignment received during this period is to be disposed of. By whom, at what time and how should this programme be made? In a word, what is the practical method to adopt? The replies of the various companies on the subject are neither unanimous nor precise.

On some systems, confidence is reposed in the men handling the goods, in their experience, etc. In our opinion, this should not be left entirely to them,

especially in the small stations where the staff does not always possess the desired education and knowledge. Without doubt, it is not difficult for an employee, to whom a single consignor remits one or two important consignments for the same destination, to see at once that they can and ought to warrant a *reserved conditional.* But the matter is not always as simple as this, especially in what concerns the groupings. Moreover, the employees may, either by routine, to avoid making inquiries or asking for wagons and putting them at the platform, or to finish their duties more quickly, etc., allow themselves to follow two tendencies equally prejudicial to the correctness of the loading and conveyance of the traffic. Sometimes they load, as quickly as possible, all the consignments in *regular* wagons, which seems to them the simplest procedure; at other times, on the contrary, as a result of reprimands in the matter, they prepare conditional wagons which they load and send off, even if the conditions required for their formation are not fulfilled.

It is preferable, we think, to entrust the preparation of the plan of work and the scheme of loading, to a qualified and specialist man, one of the office staff rather than one of the porters, knowing thoroughly the geography of the system, and that of neighbouring systems, in addition to the regulations relative to the handling of slow parcels traffic. The following method, which we take the liberty of explaining in all its details, may be applied :

For each *regular* wagon which visits it, the station keeps permanently a box for the purpose of holding the waybills, and having on its lid, the designation of the said wagon, « Collector No. 402 or distributor No. 648, or batch wagon for Troyes, etc. ».

Each box contains within it :

— a folder bearing the designation of this *regular* wagon;

— a certain number of other folders, each bearing the designation of one of the *batch conditionals* which, according to the terms of the instructions regulating the organisation, are available to be withdrawn from the *regular* wagon category.

The responsible employee receives as soon as they are ready, *and one by one,* the documents or the parcel waybills. When he receives one he searches in his table (see page 926) for the designation of the *regular* wagon, A, for example, and, when this is missing, that of the *conditional* wagon, G, for example, which are entered according to the destination of the consignment (or the transit point when a consignment is leaving the system). He puts the waybill in the box for the *regular* wagon A, but classifying it, in this box, in the folder corresponding to the *conditional* wagon G; if, in respect to the destination of the consignment he has only found in the table a single designation of *regular* wagon, A, for example, without any designation of *conditional* wagon, he places the slip in the folder appertaining to the *regular* wagon A. The man in charge takes care to classify the waybills in the alphabetical order of destination, and to pin together those of the consignments having the same destination.

Each time that he thus files the waybill belonging to a consignment whose destination is X, for example, the responsible man, by a rapid calculation, adds the weight of this consignment to that of the others for the same destination whose waybills have already been presented, an sees if the total weight thus obtained reaches the minimum required for the formation of a *fully-loaded conditional* wagon. If the result is in the affirmative, this wagon ought to be prepared and the charge hand informs the foreman shunter, who arranges either the putting in place at the desired time of the necessary wagon if the station has it on hand, or in the contrary case, its production by the responsible authority.

Then he removes from the folder and the box the waybills of all consignments directed to X, and ties them up in a bundle on which he writes *reserved conditional wagon* for X. It should be understood that from this time

he inserts in this bundle all slips which come to him for goods whose destination is X.

When, on the contrary, the total weight of the goods for X does not reach the minimum required for the formation of a *reserved conditional*, the charge hand merely puts the waybill in its place following the stipulations outlined above.

Etc., etc.

For each *regular* wagon, A, for example, the charge hand stops his operations once the « handing-in-period » for this wagon is terminated (1) and once all the waybills to go into this box are filed — waybills which he fetches as required from the office. At this time he removes from the folder applicable to the wagon A, the waybills contained therein and makes a bundle of them on which he writes: *regular wagon A*. Then he examines each of the folders for the *conditional* wagons contained in this box. If the total weight entered on the classified waybills in one of the folders, for example, that of the *batch conditional* for G, reaches the minimum required for the formation of this wagon, then it *must* be provided. The employee then withdraws these waybills and makes them into a bundle on which he writes: *batch conditional* for G. Then he informs the yard foreman who arranges either the placing in position at the required time of the necessary vehicle, if the station has it on hand, or if not, its provision by the responsible authority. If on the contrary, the total tonnage entered on the waybills contained in the folder marked *batch conditional for G* does not reach the minimum required for the constitution of this wagon, the man in charge removes the slips from the folder and adds them to the bundle marked: *regular wagon A*. He proceeds thus for each of the folders of the *batch conditionals* contained in the box A.

Finally, the charge hand finds himself in possession, so far as the *regular* wagon A is concerned, of various bundles referring to

— *reserved conditional* wagons;

— *batch conditional* wagons;

— and finally, the remainder of the *regular* wagon A whence the other wagons have been extracted.

He writes, on the waybill of each consignment, the designation of the wagon which appears on the bundle of which it forms part, and sends the bundles to the yard foreman.

The same procedure takes place with the box of each *regular* wagon.

It may happen that every *conditional* wagon thus earmarked is not loaded on the first day. We have seen (page 926) that it is more than desirable that it should set off at the latest the following day, otherwise its intended contents should be diverted on that day to the *regular* wagon going to the desired destination. With this intent, it is essential that, on the day following the reception of the goods, the station master should decide whether he will be able certainly to have the stock at his disposal and also the necessary men to load each *conditional* wagon not yet forwarded and to get it off during the day. If he has doubts about the possibility of this, he returns to the man responsible the bundle prepared for this wagon, who retains the waybills until the expiration of the working day, taking care not to mix them with those of the current day, nor to file them with the latter. At the conclusion of the current day's work, he makes them constitute the start of the bundle for the *regular* wagon whence had been removed the *conditional* wagon. It is guaranteed, in this manner, that the consignments will be, without fail, loaded during the same day in the wagon mentioned.

The classifying of the waybills ought, we insist on this point, to be made before the

(1) Nevertheless, in the small and medium stations visited by local trains the closing of the « handing-in time » for each *regular* wagon is to be made sufficiently late to enable the despatch of the maximum number of articles handed in during this period to be made, even at the last minute, and yet not too late to provide time for the transference of the articles from the shed to the stopping place of the train and so that no risk is taken of delaying the train.

loading, which is the object of the classification: the latter ought to be stopped, for a given *regular* wagon only once its « handing-in period » is at an end, and when the *whole of the waybills* referring to this wagon are ready. It could not be worked otherwise, since the method of loading of a consignment may be affected by the weight and destination of some other consignment brought to the station after the first, in fact at the very end of the « handing-in period ».

As to the entering on the waybills of the indication of the wagon in which each consignment is to be loaded, this ought only to be done once their classification is finished.

This method, which no doubt is not the only one which might be adopted, consists, in short, of applying to the waybills — which represent the goods — the rules applicable to the loading of the goods themselves; to realise by this means a classification of these waybills, in some manner, the distribution of the goods between the various *regular* or *conditional* wagons; and finally to hand over the classified waybills to the yard staff, who then have only to carry out the loading duties, whilst strictly sorting the goods according to the waybills.

4. *Loading of consignments.*

After the receipt of a consignment, the identifier, after having found in his table (see page 926), the designation of the *regular* wagon of appropriate destination, has taken care to deposit the goods in the bay of the shed allocated to this wagon.

As we mentioned above, the porterage gang receives for example : 1 bundle for the *regular* batch wagon A, 1 for the *conditional* batch wagon B, 1 for the *collector* 744, 1 for the *reserved regular* C, 1 for the *distributor* 512, 1 for the *reserved conditional* D, etc., etc. In addition, the designation of the wagon appears on each sheet of the bundle. Consequently, the porterage gang easily find each consignment and have only to load it in the *regular* or *conditional* wagon specified on the slip. This loading ought to be done as early as possible, according to the conditions described in paragraph 2 : « Period for despatching goods ».

In the small and medium sized stations, which are *visited* by *regular* wagons incorporated in local trains, it is of advantage that an order fixes, for each *regular* wagon, the exact time towards the end of the « handing-in period » at which the sorting of the waybills must be stopped, under the conditions indicated in the footnote of page 934. This order ought also to detail the instructions to be observed as regards the preparation and sorting at the stipulated time and place, of the goods to be loaded during the halt of the train.

In stations of a certain importance, which are originating stations of *regular wagons* whose departure takes place during the night, and where, as we have seen, the « handing-in period » for these *regular* wagons coincides purely and simply with the period during which the station is open to the public, loading takes place at the platform and starts shortly after this closing time, as soon as the classification of the waybills is completed. The loading is thus performed in the evening, and continues until even a late hour of the night. Some systems, however, have an objection to loading work taking place during the night, which would be slower owing to artificial lighting, and offers risks of damage and pilfering. These objections do not seem to have a serious relative weight for it is not impossible to minimise them by a good lighting installation and by suitable supervision; moreover, quite frequently, in these stations, night loading is, so to say, imposed by the necessity of :

— vacating the loading platforms for use the following day;

— effecting a correct loading, and for this purpose, we have seen that it is necessary to have possession at one time of all the con-

signments handed in, hence the evening must be awaited;

— and, finally, accelerating conveyance which is, we must not forget, the object to be attained. The advantage resulting from not waiting until the morning for loading the goods is still greater from the fact that the through goods trains travel at night time because of the fewer number of passenger trains then abroad, and in that the majority of parcels trains, in any event, set off in the early morning.

The essential thing is, that on the departure of each *regular* wagon, all the parcels intended for it brought in during its « handing-in period » immediately preceding its arrival, should be loaded into this wagon, with the exception of those which fulfil the requisite conditions for the provision fo a *conditional* wagon. In the latter case, the loading ought to be concluded so that the *conditional* wagon may get away at the latest on the day following the handing-in. If this cannot be done, and as soon as it is definitely known that such is the case, a decision must be made that the *conditional* wagon will not be provided and the parcels must, without fail, be loaded in the very first *regular* wagon of appropriate destination, which visits the station.

As stated previously, the loading can be undertaken only when the classification of the waybills has been completed, which, itself, can only be done at the end of the « handing- in period » for each *regular* wagon. Does this mean to say that the loading of certain wagons can never be started before the end of their « handing-in period »? Certain Administrations (Belgian National Railway Company, Swiss Federal Railways, Swedish State Railways, Finnish State Railways) recommend the contrary of this practice but with the object of expediting the handling and also the departure of parcels, to ease the pressure in the sheds and also to avoid their having excessive dimensions. There is no doubt, for example, that one can, without trouble, start the loading of a *reserved regular* wagon at any time during its « handing-in period ».

Likewise for a *reserved conditional* wagon, one may start on it as soon as the possibility of « extracting » it from a regular wagon becomes apparent. One can be sure, indeed, whatever the ultimate contents of a *reserved* wagon may be, that their inclusion with the articles already placed in it will not enable the latter to be loaded into a *conditional* wagon, capable of procuring for them a more direct and more rapid transit.

But, apart from the *reserved* wagons, it appears that one ought not, in principle, to start the loading of any other wagon before the end of its « handing-in period », whether it is a question of a *batch* wagon (*regular* or *conditional*), of a *collector*, or of a *distributor*, etc., because one would not have, as for a *reserved*, the certainty that any other consignment forthcoming after the start of the loading would not comprise articles which, taken in conjunction with those already loaded, might give cause for the formation of a *conditional* wagon to be « extracted » from the wagon already in hand. Supposing, for example, that one starts the loading of a *batch* wagon for a centre C with articles variously consigned for stations X, Y, Z, T, situated within the zone of C : it is possible that towards the end of the « handing-in period » of this *batch*, a trader may bring a big consignment for Z, which, together with the articles for the same destination already loaded in the C *batch*, fulfils the conditions requisite for the formation of a *reserved conditional* for Z. — Another example, one starts the loading of a *collector* for a collecting centre C^1, not far afield, and which comprises among others, goods destined for stations M, N, P, Q, included in the distribution zone of a distant centre C^{10}. There may arrive, before the close of its « handing-in period » an important consignment of goods destined for M. N. P. Q., the

tonnage of which, added to that of those already loaded in batch C^1, justifies the formation of a *batch conditional* for C^{10} to be extracted from the *batch* C^1. For a *distributor*, moreover, it is still less desirable to start the loading before the end of its « handing- in period » as it is indispensable to have ready all the intended contents, if one wishes to be able, as it is prescribed, to sort them into geographical order and to avoid any difficulty with their distribution « en route ».

These rules evidently have nothing absolute about them, and may be amended, taking local conditions into account, such as, in particular, the size of the buildings, in relation to the importance of the traffic; this is what the Administrations referred to above had in mind. But what may be said with assurance is that an article prematurely loaded risks being incorrectly loaded and thereby delaying the transport of the merchandise.

c) Working of tranship centres.

We have seen that a certain number of parcels must necessarily be transhipped between their departure and arrival points.

1. *Definition of tranship centres.*

Certain transhipments are carried out from train to train at a junction, for example, where a secondary line branches off a trunk line. But it is generally recognised that it is an advantage in reducing to a minimum the number of such transferences, and in concentrating these operations at important points, by causing the parcels wagons passing from the main line to the branch or vice-versa to call at these points. Such a regime presents several advantages : — the concentration of the operations admits of a more rational, less scattered and less costly organisation; it avoids the transfer of certain articles, and reduces correspondingly the risks of damage; finally, the gathering together of the goods at a single point favours the formation of *conditional* wagons both of the *reserved* and *batch* variety, to the advantage of more rapid transit.

We call « tranship centres » these important places towards which regularly converge large numbers of parcels; the contents of which are methodically transferred into other wagons.

The majority of the Companies have centres of this nature, varying in number according to the size of the system, its geographical structure and the plan of its lines, and also according to the kind of organisation adopted by it for the transport of slow parcels traffic. In spite of the natural desire which one might have, it is better not to reduce too greatly the number of tranship centres, because it is evident that by pushing things to the extreme, one would cause to be accomplished by certain goods, as much to reach a too far distant centre as to remove them thence, journeys considerably longer than the direct trip from their point of departure to that of their destination; and one would in consequence, certainly lengthen their time « en route ». These tranship centres ought to be suitably chosen, as much from considerations of their respective distances as of their location. As a rule it is advantageous to place them at sorting sidings, points of origin and termination of trains, without on the other hand there being any necessity to provide them at all sorting sidings.

2. *Hours and days of work in these centres.*

The tranship depots have very variable working hours according to the systems: here it is 24 hours, there 18 hours, and elsewhere 8 hours only. It is usually arranged, and that is only natural, that they depend upon the times of departure and arrival of the trains bringing wagons for attention, and namely the stopping trains which, as a rule, arrive rather late in the evening and depart somewhat early in the moring. This explains that, in most cases, the working of these depots occupies, if not all the night, at

least the evening. Do the tranship centres remain open on Sundays and public holidays? According to the information received, they are closed in Sweden, Norway, Switzerland and Holland, and on the French Nord system; they are, on the contrary open in Finland, on the Madrid-Saragossa-Alicante Railways and on the French systems other than the Nord. It seems that the closing of the depots on those days, leads infallibly to a delay of 24 hours for the goods, since the arrival of the wagons, coming from all directions and all distances is approximately continuous. It might be asked whether all the systems will not be induced by the pressure of road motor competition, to keep their depots open on Sundays and public holidays, in order to avoid delays. The case is different, from this point of view, from that of local stations, where no reception takes place on Sundays, making it permissible to do no handling work, provided that, by Sunday morning all packages handed in on the Saturday are loaded and despatched.

3. *Lay-out.*

The tranship lay-outs vary greatly in design, not only according to the countries and the systems, but also within a given system. This arises from progressive developement of design and perhaps also from the fact that originally there was not definite and systematic technique for the performance of transhipment.

The lay-out, which we should describe as « elementary », consists simply of a loading platform situated between two sidings.

In the more modern lay-outs, built specially with a view to transhipment, several platforms with sidings are added

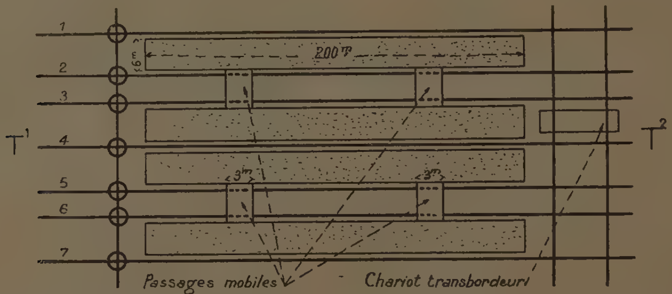


Fig. 2. — Transhipment depot for slow parcels at Vaires sidings (French Est Railway).

Note: Passages mobiles = Movable gangways. — Chariot transbordeur = Tranship truck.

to the above; sometimes, there is placed in the middle of the structure, between two of the platforms, a single siding called the central road (see fig. 2). Communication between the various platforms for the passage of barrows is provided either by means of drawbridges which are raised and lowered by hand or by means of an electric motor, or by means or rolling bridges which, when required, may be slued out of the way on tracks fitted under the decking of the platforms.

The general arrangement of such an installation is as shewn in figure 2.

Sometimes some of the sidings come

to a dead end at one extremity of the lay-out; this arrangement may, moreover, be adopted for the provision of traverses.

Finally, some designs embody sidings arranged in echelon (see fig. 3): this

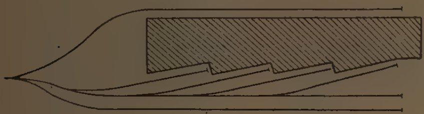


Fig. 3.

form of plan has the merit of enabling certain wagons to be placed in position and withdrawn without interfering with others and in consequence without interrupting their tending. It necessitates, however, more frequent and consequently more costly shunting.

4. *Methods of transhipment.*

The replies which have come to us shew that the transhipment is performed in different ways, according to the Administrations.

On some systems all that is done, in fact, is to « retouch » the incoming wagons; when one of them contains a certain quantity of goods, or what is called a « remnant of a wagon » which authorises their continuation, if not so far as their destination, at least to a near-by centre, these goods are not unloaded; all that is done is to remove from the wagon and deposit on to the platform those goods which do not have to go in the same direction as the « remnant » and to add thereto those goods going in this direction and emanating from wagons which happen to be present at the same time or which have been discharged previously. The wagon is then drawn from the platform and sent off. This method of procedure clearly has the object of reducing transhipment to the absolute minimum, but it is under the reproach of being by no means methodical, and particularly of not permitting, for the various goods coming to the centre, a « correct » loading with the formation, whenever possible, of « *conditional* » and through wagons, so as to speed up transit. In this way much stock is used up, whilst not procuring for the goods the rapid carriage which they would benefit by if properly loaded in *conditional* wagons.

Sometimes the incoming wagons are completely unloaded and *all* goods are dumped on the ground at pre-determined spots preparatory to re-loading them in the wagons thus emptied with which is constituted the string of *regular* wagons serving the station for outgoing traffic and eventually the *conditional* wagons as necessary. This method enables an absolutely « correct » loading to be made for outgoing traffic, exactly as would be done in a local station for goods brought in by customers. It is, moreover, of necessity, made use of when the centre, being itself an important « local » station, does not possess any special shed for transhipment, in which case transfer takes place in the « outgoing » shed of the « local » where the goods for transhipment are deposed, according to their destinations, in the same bays as those which enamate from the « local ». But it necessitates the unloading, the placing at the platform and the reloading of the bulk of the goods, that is to say, a lengthy and costly double handling; it also exacts platforms of great length on which, at one time, may be deposited the goods and the barrowing operations performed.

Finally, at some places, the method known as « direct transfer » is practised, which is the following : One places at the platform a sufficient number of empty wagons, with the object of constituting with some of them *regular* wagons whose use is already foreseen by the central organisation, on their departure from the given « tranship centre »;

with others, *conditional* wagons. These wagons remain in place, for example, on roads 1, 2, 3, 5, 6, 7, during the whole of the period of work, which enables the bridges to be launched forming communication between the various platforms (see fig. 2). Moreover, the wagons whose contents are to be transhipped are brought successively to the platform, on one of the roads specially allotted for this purpose, for example, the centre road 4. A preliminary preparation work, to which we will refer again later, has enabled to be written on the waybill of each of the consignments contained in the incoming wagons, the *regular* or *conditional* wagon, in which it ought to be reloaded. When the wagon is opened, a worker hands to the barrow man each consignment with its waybill, and the barrow man takes is *directly and without dumping on the platform* to the wagon to which is has to be transferred. When all the incoming wagons have thus been placed at the platform, the transhipment is brought to an end, and the goods are thus loaded into the wagon detailed to carry them as quickly as possible to their destination. In truth, however, one cannot dispense with putting at the platform those goods intended for a *distributor wagon*, which must indeed, in order to be able, without loss of time, to be distributed « en route » in the stations, be classed in the geographical order of the latter. It is therefore indispensable, for this, only to start the loading when there is assembled on the platform, near to the distributor, the whole of the goods intended for the latter.

This method offers the advantage by eliminating almost entirely dumping and picking-up from the platform of reducing very materially the handling work and in consequence the expense. But it is evident that it does not permit the realisation of a loading so « correct » as with the preceding method. With this one can, in effect, just as in a local station, proceed in a complete manner to a preliminary classification of the consignment waybills, which is an indispensable prelude to their « correct » loading (see page 934), for the loading is started only when all the goods are ready on the platform and the *whole* of their waybills are at this moment likewise to hand. In the method of « direct transhipment » on the other hand, loading starts as soon as work begins : if there are, for example, 100 wagons to be transhipped, there continues to arrive at the station and at the depot, during the 8 or 16 hours duration of the session, further wagons to be transhipped. At no time is there in hand the *whole* of the goods to be transhipped, and only the waybills of the first 100 wagons can be classified before starting operations. If subsequently 50 others arrive, one may, before opening them, proceed with the classification of their waybills, but it is no longer possible to unite this classification with the first one, and as a result there is missed, for example, the formation of a *reserved conditional* for a station X, because in the first 100 wagons there were only 900 kgr. for X, although 1 200 kgr. for this same station are revealed at the scrutiny of the waybills for the other 50 wagons. In spite of that, the economy of labour and the gain in time which the method of « direct transhipment » procures are such that these advantages appear to outweigh the inconveniences.

Besides, it enables a reduction in the width of the platforms to be made, since, in principle, these ought to serve only for the barrowing of the goods and not for their deposit. As to the length and number of the platforms, these may require to be slightly increased by reason of the fact that it is necessary to be able to put in place at the same time, during the whole of the working hours, *all* the *regular* and *conditional* wagons which have to be constituted. There is, moreover, in the design of the depot,

a proper ratio to be found between the number and length of the platforms, having regard to their width, with the object of obtaining, for the average trip necessary in the moving of the goods to each wagon, the minimum displacement. Experience shews that for 130 to 140 wagons, both *regular* and *conditional*, to be put in place, good results are obtained by building a depot having four platforms 200 m. (656 feet) long and 6 m. (20 feet) wide, served by 7 roads, of which 6 serve for the standing of wagons to be loaded, the seventh being reserved for the occupation of wagons for transhipment. This is the lay-out adopted by the French Est Company for its slow parcels tranship depot at the Vaires marshalling yard (see fig. 2).

In fact, on the different Systems, one or other of these methods is employed, according to the extent of the traffic and the equipment of the stations, but in the important centres provided with modern installations, there is a tendency to adopt the method of « direct transhipment ».

It is useful that there exist at each end of the tranship depot proper, some spare standing room (see T^1 and T^2 on figure 2). In one of these places, for example T^1, there are stored the wagons to be transhipped, which are shunted directly thereon in rakes; on the other are withdrawn and parked the wagons just emptied, whilst they are waiting to be put in place for the subsequent tranship session. Generally, there exist, on each side of the depot, turntables or better, traversers worked by steam or electricity. These appliances serve for distributing vehicles on the various roads, for the placing in position of wagons in case of the duplication of an inadequate *regular* wagon, or for the formation of *conditional* wagons. In the « direct transhipment » regime, the bringing in, by cuts, of wagons for transhipment is generally performed by means of an engine or of a tractor which also removes them when they are empty. When the roads do not terminate in a dead end this service may be conducted « continuously » by moving the wagons always in the same direction, for example : entry, side T^2 and exit, side T^1.

As to the wagons to be loaded, it is generally an advantage to arrange them at the platform so as to group those which must leave by the same train, so as to be able, at the last moment to withdraw each group for the purpose of taking it directly to the train in which it is to be incorporated. Thus these wagons are not subjected to any gravity shunting with its attendant risks of damage.

The whole of the depot is roofed in to shelter the workers and protect the merchandise from wet. The platforms are numbered; on each of them and at the entry to the bridges which connect them, notices state the designation of the wagons under loading on each side of the platform, for example, collector No. 410; batch wagon for X; in front of each of these vehicles a notice repeats its designation. In this way the barrow men circulate just as they would in the streets of a district and can easily identify the wagon to which they must convey each article, thereby accelerating the work of porterage. As to the lighting of the platforms, this is generally assured by means of electricity. Portable lamps attached to holders connected to plugs are used for lighting the interiors of wagons. Finally, the accommodation is completed by an office, a room for the porters, and a shed for tackle (blocks, spare parts, etc.).

d) Operations at the arrival stations.

The part played by arrival stations in the matter of slow parcels traffic is relatively passive.

Certain Administrations allow stations to detach, in certain cases and in particular when the train is running late,

regular wagons whose terminal is situated further on.

We consider it better to prohibit this practice. It is « en route » and whilst a train is standing that a station ought to load the goods into such a wagon, or to unload them. The timetable of the stopping train, whose business is precisely that of serving the stations, ought to be arranged with this object. Now, stations are often tempted, with a view to effecting this handling work more conveniently in the shed, to uncouple the wagon and forward it in the next train, sometimes on the following day, and they are often very happy, for the justification of this act, to invoke their desire to avoid any delay to the train. Such a tendency is regrettable, for it has the effect, in return for a minor convenience reaped by a station, of delaying all the other goods contained in the wagon, and this delay becomes absolutely inadmissible if several stations along the route act successively in the same manner. It is preferable, in our opinion, to impose a delay upon a slow stopping train rather than upon an entire wagon load of parcels.

Summary concerning the carriage of slow parcels traffic.

As we have seen, the various Administrations possess for the above traffic, organisations of a somewhat comparable nature, by virtue of which every station ought :

— Firstly to endeavour to draw up for the loading of its packages a programme *peculiar to each day,* specifying the making up, according to certain fixed rules taking into consideration jointly the destination, the weight and the volume of the various consignments which it possesses, of through *conditional* wagons which procure for them a safe and expeditious transit;

— and, for those goods which do not fulfil the requisite conditions for taking their place in such *conditional* wagons, to send them in conformity with a *general plan of transport* for « regular » wagons in daily circulation, each of these receiving the goods sent to specified destinations. This plan is drawn up, having regard to the number and to the appropriation of the *regular* wagons so that whatever may be the destination of a consignment, each station has a *regular* wagon available for its reception.

It is permissible to ask oneself whether, in their conception as well as in their execution, these organisations have evoluated sufficiently to answer the needs of the present day, and to enable the railway to combat road motor competition which the great and rapid progress in automobile design has made particularly severe during the past few years. We do not think so. There is no doubt, for example that some Administrations adhere too closely to the principle of the « best possible utilisation » of stock. Some sacrifices in this direction — and in others also — ought to be consented to by the railway if it wishes to regain the slow parcels traffic which it has lost and not to see itself entirely deprived of this traffic. It is necessary that it should achieve, in order to avert this possibility, a highly expeditious transport of traffic, and if possible from door to door.

The basic organisation, that is to say, the one which, covering all the lines of a system with *regular* wagons, ought to enable any station whatever to forward daily consignments to any other station whatever, is to be put into operation on each system, having consideration for the various factors of the problem, but with the essential objective of rapidity of transport. We have indicated, at the beginning of this analysis, the various regimes which may be contemplated, with their advantages and their disadvantages.

No matter which one is adopted, however logical and complete it may appear, we believe we have demonstrated that no rigid system of organisation could, *a priori*, be considered as being capable, by itself alone, of procuring a solution to the problem of rapid transport by rail. The organisation ought to be flexible and adaptable to requirements which are diverse; for that, the system ought constantly to inform itself, by periodical analyses, of the magnitude and direction of its slow parcels traffic currents, and this should be done not only for the traffic which it at present carried, but also for that which it may have lost, owing to competition.

It seems worthy of recommendation that when the existence of a noteworthy and above all regular current is revealed, there should be no hesitation, even if their use might not be satisfactory, to cater for it by one or more *regular* wagons, that is to say, running daily (in some cases even twice daily) and *through's (reserved or batch wagons)* with the object of obtaining *rapid* transit. As to those currents which, on the contrary, do not offer any steady aspect of regularity, but shew themselves by pulsations of a certain strength, these also should not be ignored. In order to ensure for them rapidity of conveyance it is necessary materially to reduce the usual tonnage required for the formation of *reserved conditionals* or *batch conditionals*. In a word, there is advantage in multiplying *through* wagons whether they be regulars or conditionals, the basic organisation, with its collector, and distributor wagons, etc., remaining reserved for isolated consignments, forwarded without any regularity from any point to any other point. This multiplication of through wagons is not without its effect in increasing traction and shunting costs; it is necessary to make up one's mind to this.

The train organisation would likewise require modification, with a view to detaching, as we have pointed out, the service of slow parcels from that of fully laden wagons and to ensure in the stations every evening, and no longer at any time of the day, the collection by a train with accelerated speed of the goods handed in by the public. Therein lies a means of ensuring a rapid departure of the goods. It would even be desirable, if possible, to arrange the distribution also, every morning, of the goods intended for these stations. The organisation introduced with this object by the Reichsbahn, in the form of the « Leig », deserves to be followed with the greatest attention, as much for its economic results (costs, etc.) as for the effect which it may have on the retention of parcels traffic by the railway. Practically the Reichsbahn has pursued and reached, among others, the following objective : Being given the articles brought into the small stations by the consignors in course of the day, to put them at the latest on the morning of the following day at the disposal of the consignees, in the small stations situated within a radius of 200 km. (125 miles). This obviously constitutes a most interesting achievement in the struggle to be waged against motor competition. Doubtless certain Administrations will undertake trials of the « Leig » method.

Outside the general organisation itself, certain rules and methods of procedure appear to us to be of such a nature as equally to permit the railway to increase the efficiency of its slow parcels business. We have investigated them in the course of our study and will recall them here succinctly :

— It is necessary strictly to fix the duties of the stations, to ensure quick despatch and « correct » loading of the parcels. For quick despatch, a simple rule is to prescribe obligatory departure of the goods by the very first *regular* wagon of suitable destination which visits the station after their handing-in, or, if there is occasion to constitute a

conditional wagon, the departure of this on the day following the handing-in at latest. It would seem desirable in any case, absolutely to prohibit the stations from keeping goods for two days or more with the only object of endeavouring to form a *conditional* wagon; we have emphasised the abuses to which such conduct leads. As to the « correctness » of the loading, it is impossible to stress too much, that for its attainment, recourse should be had to the preparation of the « handling programme » which has been defined earlier in this report. The provision of this programme, which is to be confided to a suitably qualified person, enables an accurate determination to be made of the *conditional* wagons eligible for « extraction » from each *regular* wagon and, finally, to designate exactly the wagon, *regular* or *conditional* in which should be loaded each consignment, taking account of its charcteristics and of those of the other goods brought in during the same *handing-in period* of a *regular* wagon.

If there is thereby obtained an immediate putting into traffic and a « correct » loading, it may be asserted that much has been done to ensure rapid transit.

Sacrifices have to be made to speed up the handling, in the departure stations, the arrival stations and in the tranship centres by the use of mechanical appliances — tractors, elevator trollies, containers, this last term being taken in its most general sense to include boxes, trays, trucks, etc. — all devices capable of themselves being loaded in the wagons with the goods which they contain or support. The saving in labour which results, the rapidity of loading and the reduction of damage, compensate in an appreciable manner for the capital invested in this mechanical equipment.

The special classification of the parcels wagons in the trains could, with advantage, be generalised. This gives rise, it is true, to shunting costs, but it accelerates the movement of these wagons and, in avoiding any gravity shunting, decreases risks of damage.

— Priority, as regards incorporation in the trains, ought to be given to parcels wagons over other wagons, except those carrying cattle or perishable commodities.

— The application of the « direct transhipment » method, at the tranship centres whose equipment permits of it, jointly with the use of mechanical appliances, appears to accelerate the handling and consequently the conveyance of the parcels.

— The exercise of a vigilant supervision is necessary; that the rules relating to the slow parcels traffic should be strictly observed must be the object of local surveillance. But the best thing is to verify the actual conditions appertaining to the transport of the merchandise, either on the occasion of delays and complaints, or by tests made at hazard. The inspection of the waybills and the stamp markings which must be placed upon them at stations where they are dealt with, shews clearly any mistakes made as well as any defects or errors which may exist in the organisation. It is thus easy to deal with the former and to remedy the latter.

Above all, what is necessary, is to educate the workers, to draw their attention to the reasons which exact rapid handling of parcels, even to excite their emulation as regards competition, and to instill into them the idea that they ought to apply faithfully the prescribed rules, equally at departure, arrival and during the conveyance, in the handling operations and in the shunting work, and to do their utmost to avoir any delay either to wagons or to parcels.

CHAPTER IV.

Appliances used in the handling of parcels.

In order to reduce the loss of time, to avoid damage and to use the personnel in a rational manner, it is advisable to place at the disposal of the men in charge of handling work equipment suitable for the work undertaken.

On passenger platforms, barrows and trollies of different patterns are made use of. In order to facilitate the loading and unloading of heavy articles, trollies have been constructed whose floor is approximately at the same level as that of the railway wagon. On one of these appliances frequently used in France (Noël truck) automatic braking whilst stationary is obtained simply by raising the handle by means of which the machine is controlled.

Trucks have also been invented whose floor may be raised or lowered at will so as to reduce to a minimum the force necessary to load or unload the goods.

The trucks concerned may be pushed by hand or driven by motors, either electric or petrol. In general, use is made of tractors which can tow a certain number of trucks coupled behind them.

In a general way, when it is a question above all of operations performed in a shed and for fear of risks of fire, it is preferred to use electric apparatus, fed by accumulators. It is thus that the *Satme* tractor is frequently used in France; it is fitted with a battery of 27 nickel-steel cells, having a capacity of 190 ampere-hours with a normal charging and discharging current of 45 amperes and a mean discharge pressure of 1.2 volts.

Various Administrations have communicated to us the financial results obtained by using such tractors with suitable trucks. Let us quote, for example, the Swedish Railways, which use an apparatus whose price is 13 250 Swedish crowns and which produces an annuel economy of 3600 crowns. The French Paris-Orleans System estimates that the use of these appliances permits a saving of 10 % on the handling costs per ton.

In taking special precautions against fire, use may also be made of petrol tractors which seem to produce advantages of the same order. As an example we will mention the appliance used in France (*Billard* truck) whose characteristics are as follows: 4-cylinder engine developing 9 H. P. at 1 500 r. p. m. The weight of the truck is about 900 kgr. (1 980 lb.). Its dimensions are as follows : length 1.83 m., width 1.00 m. (6 ft. × 3 ft. 3 3/8 in.). It can negotiate a curve of 1.40 m. (4 ft. 7 in.) radius. A gear box enables it to travel at 5 or 10 km. (3.1 or 6.2 miles) per hour. The tractive effort is 450 kgr. (990 lb.) in first gear and 225 kgr. (495 lb.) in the second.

The trucks (trailers) on which the goods are placed are often fitted with ball bearings and rubber tyres to increase adhesion and prevent noise. In the same depot several types of trucks are used, some are designed specially to carry a certain class of goods : carboys, bulky articles, castings, etc. The nature of the equipment of trucks ought to be determined according to the uses to which they are to be put.

It may be of advantage to run the tractors and the trucks actually into the wagons to reduce the amount of labour or at least to allow them to pass through the wagons in going from one platform to another. In order that these movements may be conveniently carried out, the floor of the wagon should be at the same level as the top of the platform, and it is useful to have metal bridges of shallow depth.

The trucks or trollies enable the shifting of heavy masses of goods to be performed which, without them, would often be individually transported by means of barrows and hand carts. The economy

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

resulting is particularly considerable when numerous small parcels for express conveyance are concerned.

In order to reduce handling costs to the maximum extent there is encouragement to use a large number of trucks in a depot. But these remain immobile for long periods and their periods of working are often very short in the course of the day. Hence comes the idea — for reducing the capital expended on material — of separating the deck of the truck from its chassis. There are then used simple platforms resting on four legs or on rollers, and hand operated hoists (see figs. 4, 5 and 6). In order to move a platform, one of these portable hoists is slipped under it, which raises it when the control lever of the apparatus is depressed. On ar-

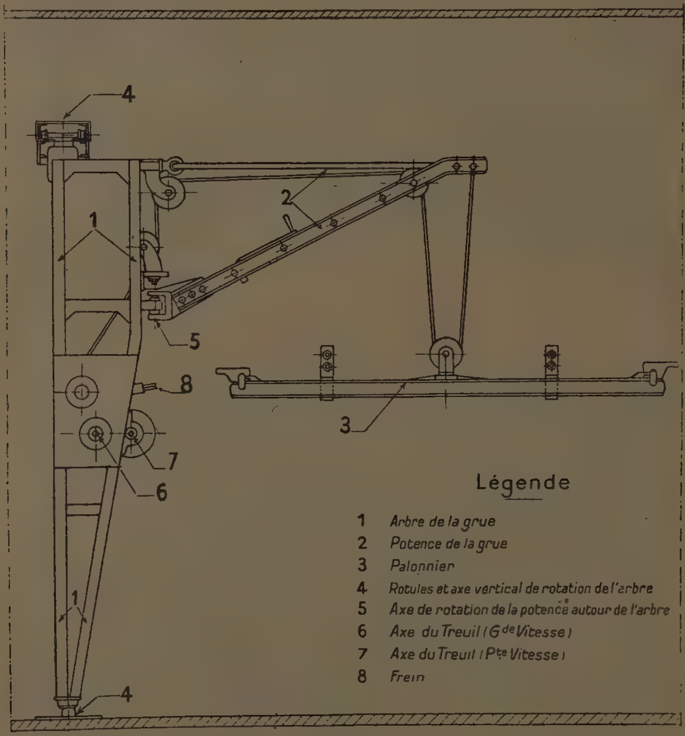


Fig. 9.

Explanation :

1. Crane post.
2. Jib.
3. Load-carrying beam.
4. Spherical pivot and axis of rotation of post.
5. Slewing axis of jib about crane post.
6. Axis of winch (high speed).
7. Axis of winch (low speed).
8. Brake.

Fig. 10.

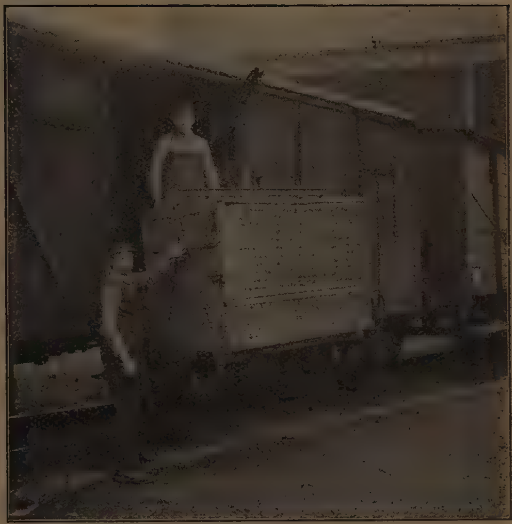


Fig. 11.

rival at destination, the lever is raised again and by means of suitable mechanism the platform resumes contact with the ground (see figs. 4, 5 and 6). Instead of hand-operated hoist trucks of the preceding type, electrically driven hoist trucks are used which, when introduced in the same way under the platform, raise it and carry it, but much more quickly, from one end to the other of the depot and, as required, place or displace it in the interior of a wagon (see figs. 7 and 8).

With some of these trucks, a large number of platforms can be transported in a depot thereby realising very appreciable economies.

When slow parcels are concerned, it is sometimes necessary to shift heavy articles. In this case use is made of tackle which may be operated electrically if its use is frequent. In order to obtain horizontal movements of a certain extent, these lifting tackles are mounted on wheels which travel on a runway. This equipment, commonly known as a « monorail » necessitates the installation of special framework to support the runway, and the loads carried by the tackle. If it is desired to serve various sites scattered over the area of the depot, it is necessary to erect multiple runways along with switches or turntables. The installation soon becomes complicated, particularly when electric lifting tackle is concerned, and,

in consequence, also very costly. Therefore, these appliances are only rarely used.

In depots, where heavy loads have frequently to be moved, small cranes are often erected, capable of limited displacement along rails, or even self-propelled cranes may be preferred. These cranes are worked by hand or electrically.

In order to utilise the full capacity of the wagons or to reduce the floor area occupied in the depot by goods deposited there, it is necessary to place some of them on the top of others. For this purpose the railways use appliances of various kinds which are commonly known as « stackers ».

When the reception and loading of merchandise takes place on various storeys of the depot, use is most often made of electric elevators. For the sake of economy, and to obtain a greater output, chutes may equally well be employed, but these are only advisable for non-fragile and suitably shaped articles.

It may further be mentioned that sometimes transporters on rollers and belt conveyors are employed for obtaining horizontal movements, but their high cost price prevents their frequent adoption.

To conclude the question of appliances for handling purposes we will add a few words about the plant described above, which the French Est Railway uses to obtain rapid handling during stops at stations. With this object, use is made at the start of cage trucks in which all the small parcels for a given station are assembled. In order to effect conveniently the loading of these trucks in the wagons and their discharge during train stops, a light crane has been constructed in the wagons, specially designed for the purpose. This crane is fixed to the wagon door pillar and can easily be transferred from one door to the other.

The above photographs, figures 9, 10 and 11, will enable the working of the apparatus to be understood.

The first trial has been made on the brake vans which distribute on the Est system, loads of fish coming from Boulogne-sur-Mer. The capacity of the trucks used enables the placing therein of as much as 400 kgr. (880 lb.) of these commodities. At a single stroke are discharged a great number of small boxes whose handling one at a time took a long time ; in practice, the operation necessary to put out a truck takes less than one minute. It is also worth mentioning that the risks of overlooking articles and of damage being caused are considerably diminished by the above method.

CHAPTER V.

Summary.

In the course of our investigation, we have naturally been obliged to bring to light what the Companies have already done to improve the transport of parcels by « railway » that is to say « on rails ».

There is, we have seen, still room for material progress to be made from the point of view of rapidity, but this is not all, for the superiority of the automobile is to be found above all in the facilities which this means of transport offers to the public, in relieving it of the worry of cartage from domicile to station on departure, and from station to domicile on arrival.

This solution of the « complete » problem of transport of a parcel consists in getting as close as possible to the ideal solution which would be to take the parcel from the domicile of the consignor in order to convey it *economically*, *rapidly* and *directly* to the domicile of the consignee.

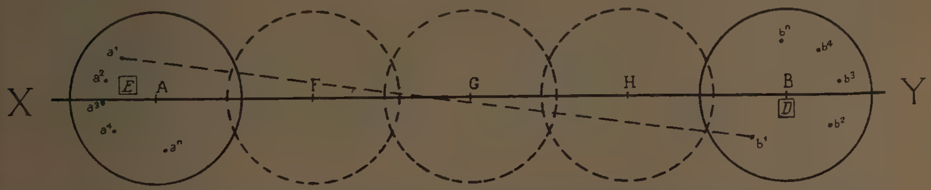
In practice, it is difficult to conciliate these three elements : economy, rapidity, absence of transhipment.

Indeed, this problem, in its most general form, *i. e.* the transport of a parcel

between two points of no rather small importance, situated at a fairly great distance apart from one another, can be represented diagrammatically in the following manner :

a^1 being the sending point, b^1 the finishing point and X Y the railroad which links approximately the route from a^1 to b^1.

This line is interspersed by stations



A, F, G, H, etc... B, having a certain importance by virtue of their geographical situation or their own traffic; a^1 and b^1, moreover, may be themselves stations of small importance on the line.

Let us consider at first an automobile undertaking of some importance : it is quite evident that in almost every case it could not undertake by automobile the *through* transport from a^1 to b^1 of a parcel, for such a transport would be of a prohibitive price compared with the value of the parcel itself.

The obligation to maintain the cost of transport at a permissible figure consequently leads this undertaking inevitably to collect by van all the elementary consignments a^1, a^2, a^3 .....a^n of a single district and to cause this van to call at a depot E, equivalent to a station, where the goods must be re-arranged and grouped according to their destinations. It is thus that all the goods of destinations b^1, b^2, b^3...... b^n will be assembled at the depot E in a van for D, the distributing centre for the regions b^1, b^2, b^3 ...... b^n. It should be noted, in passing, that quite often, the depots E and D will be located in fact in the very districts served respectively by the stations A and B, for, by definition, the depots E and D are situated in an important neighbourhood, regional centre for the small localities a^1, ... a^n and b^1 ...... b^n, which centre is generally placed on a railway line.

Let us now consider the Railway. The least that it can claim is not to loose the transport from E to D, or rather from A to B, of the goods thus grouped. It is necessary for this :

1. That the depots E and D should be established as much as possible in the station itself : A and B, each of these stations having simultaneously to play, for the localities in its zone, the role of grouping centre for despatching, and of distributing centre for receiving.

2. That the Railway should set up, for the transport in wagons from A to B, conditions of speed and price more advantageous than those of road transport between depots E and D.

For the first point, the regime contemplated would lead to a very sensible change in the present mode of operation of the lines for parcels traffic. Instead of sending into *each* station the van which collects the goods in the locality served by it, which is done today for the regular railway connections, there would be concentrated in a selected centre-station, on which vans collecting in various districts of the surrounding region would converge, the departure of goods collected by them. The transfer to stations A and B of the depots E and D appears, moreover, to be an economical solution of the problem, for it is certain that a station with its yard and its sheds already built, constitutes a depot quite suited to the purpose, preferable to those which might be constructed or rented at heavy cost in a

town, and it is not improbable that the automobile undertakings would be willing to make these the centres of their activities.

The second point raises two questions, the « price » question and the « time » question.

So far as the price question is concerned, a simple formula springing from automobile practice (wagons offered to collecting agencies for a rate per kilometre of X francs, for example) would have to be considered in order to induce these agents to prefer, to road transportation, the loading into wagon at A, and rail transport to B, to the address of an agent who would distribute the goods to the consignees.

As to the « time » question, it would be necessary that the sum total of the period en route

a^1 . . . . . A ———————— B . . . . . b^1

automobile *railway* *automobile*

should not exceed that of transport by road from end to end.

With this object in view, the Railway ought :

a) to co-ordinate carefully in each centre station the arrival of the collector vans, and the departure of the wagons removing goods and, in the opposite sense, the arrival of wagons containing in-coming goods and the departure of distributing vans.

Practically, as collection takes place towards the end of the afternoon, the departure of the wagons ought to be timed for the evening so that the transport may benefit from the night period following on the handing-in of the goods.

On arrival, the wagons ought to be on hand in the stations at an early hour so as to permit of the departure of the distributing vans in the early morning.

b) to accelerate, to the maximum extent, by specialising them, the trains conveying parcels wagons : each line ought to be served daily by two trains ; in the morning by a distributor train and in the evening by a collector train. These trains would be lightly loaded and would stop only at the centre-stations.

The risk on those systems where there is a regime of slow parcels traffic and one of express parcels traffic working together, is to see the latter ousted by the former, but there exists no doubt that this eventuality is greatly preferable to that of total loss of traffic.

But, it will be asked, ought the Railway to concern itself solely with long-distance rail-borne transport ? Is it rather not better business for it to organise collection and delivery by vans in order to retain what might be termed the carrier traffic ? The question is open to discussion, and does not seem, in any case, capable of a general answer. The solution, indeed, may vary according to the countries, their legislation and their economic regime as regards transport by rail and by road. It may even vary, within a single country according to the railway systems, the configuration of the regions served by each of them, the nature and direction of the traffic, etc. The solution must then be investigated for each particular case.

In short, it seems that the Railway, if it does not wish to find itself losing the parcels traffic and if it wishes to recover that which it has already lost, ought to organise the transport of these goods from door to door quickly and at suitably graded tariffs, by combining road and rail, according to a regime of centre-stations similar to that described above, and apt to favour the grouping of the packages. The Railway could, as the case demands, either undertake entirely this mixed transport itself or abandon to competing undertakings or to an appointed agent the duty of collecting the goods and distributing them by road vehicle in the localities surrounding the centre-station.

[625. 144 .4 & 625. 17]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION II:

The use of mechanical appliances in the permanent way maintenance and in track relaying.

REPORT No. 3

(All countries except America, Great Britain, Dominions and Colonies, China, Japan, Belgium, Spain, France, Italy, Holland, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland),

by Mohamed Kamal EL-KHISHIN Bey,

Principal Inspector of the Engineering Department, Egyptian State Railways.

Before starting my report, I find it my pleasant duty to express sincere thanks towards those Administrations that have so kindly, promptly, and carefully replied to the questionnaire sent them by me and who have helped greatly in making this report instructive and useful.

This report might however have contained more useful and varied informations had all Administrations whom I approached taken notice of the questionnaire and sent in their replies.

It is therefore to be regretted that a few Administrations did not take any notice and sent no reply. The replies received from some Administrations were so brief that they were of little value in throwing light on this subject, and it is hoped in future that those Administrations will be more generous in their replies, thus helping in the examination and discussion of different methods and their suitability to various conditions.

Question sheets were sent to 13 Railway Administrations, of which 8 did reply thus showing a percentage of 61.5.

Taking into consideration the length of lines operated, these 13 Administrations possess 116 083 km. (72 030 miles) out of which those Administrations who have replied work 84 792 km. (52 690 miles), showing a percentage of about 73.

The questionnaire sent to the Railway Administrations concerned is reproduced hereunder :

Question 1.

Will you please let me know if you are making use of any mechanical appliances for the works or parts of works mentioned hereunder in maintenance or renewal of track?

A. — *For formation of embankment and cuttings :*

1) Cleaning side ditches in cuttings.

2) Maintaining side slopes.

3) Consolidating newly filled earth.

B. — *For the ballast:*

1) Breaking up.
2) Loading and unloading.
3) Transporting.
4) Cleaning so as to maintain its permeability.
5) Consolidating inferior layer when renewing same.
6) Weeding.

C. — *For sleepers:*

1) Adzing and boring.
2) Loading and unloading.
3) Taking up old and laying new in place.

D. — *For rails:*

1) Loading and unloading.
2) Bending if any.
3) Cutting.
4) Drilling.
5) Straightening.
6) Taking up old and laying new.

E. — *For renewing whole track:*

1) Taking up completely assembled old track if any.
2) Unloading and laying completely assembled track.
3) Tightening coachscrews.
4) Tightening fishbolts.
5) Raising track to desired level.
6) Packing ballast.

F. — *For turnouts, etc.:*

1) Loading and unloading.
2) Laying.

G. — *For station yards:*

1) Cleaning.

H. — *Removal of snow from track.*

I. — *Removal of sand drifted on track.*

J. — *Distribution of small materials on the lines.*

K. — *Conveyance of men and inspectors on the line.*

L. — *Track testing machines.*

Question 2.

Where such appliances are used, kindly give full description of same with drawings or photographs or at least sketches, showing details of the different phases of operation of the machines.

Question 3.

Please also mention the cost of such machines and the power source.

Question 4.

Kindly give fulls details of their capacity in comparison to hand labour and the cost per unit at which they do their work as compared with hand labour (It is understood that in comparing the output cost of the machines, a certain amount for depreciation and maintenance is to be considered). If the work done by the machines is not more economical than hand labour, please mention reasons of preferring same to hand labour.

Question 5.

Please mention the time during which you have been using the machines and the total amount of work done and state your opinion about the machines being: 1. practicable; 2. worked by skilled or unskilled labour; 3. worked the whole year round, and mention their principal defects if any.

Question 6.

In case chemical processes are used in some of the works mentioned in *Question I*, please give full details of the processes and economies due to same.

The replies from the Administrations concerned are summarized hereafter.

Germany.

German State Railway Company (Reichsbahn).

The reply was brief and referred to Dr. Müller's report on question IV of the

agenda of the Congress held at Madrid in 1930 (see *Bulletin of the Railway Congres*, March 1930 number, pages 1079 to 1159).

According to the reply and to Dr. Müller's report, mechanical appliances are used for a great number of operations.

Going through the different operations and in the order of the question, appliances are found to be used in :

1. Consolidation of earth in new filling; this is done by rollers of 12 H. P., worked by crude oil or benzol. The rollers are three-wheeled weighing from 5 to 6 tons and cost 11 000 Reichsmark.

On page 1084 of the monthly *Bulletin of the International Railway Congress Association*, March 1930 (English edition), figure 1 is a photograph of this roller at work; figures 2*a*, 2*b*, 3*a* and 3*b* show its transportation (1); the economy resulting is enormous.

2. Machines are also used for unloading ballast and transportation of same; for this the German State Railways use self-discharging wagons some of which are illustrated in Dr. Müller's report on pages 1088 and 1089 of the *Bulletin* for March 1930, figures 4*a*, 4*b*, 4*c*, 5*a* and 5*b*.

The capacity of each wagon is 12.5 m^3 (16.3 cubic yards), the load 20 tons. The price of one wagon is from 5 000 to 7 000 Rm.

For the sake of economy it is advisable to use complete trains and not single wagons. Wagons of this kind are also very satisfactory owing to the fact that ballast can be conveyed to the desired site and unloaded to the required amount.

3. For consolidating ballast, the rollers mentioned in § 1 to consolidate earthfilling are used in this operation. It is recommended that the ballast should not be compressed more than 20 %, in order to maintain its elasticity.

4. For killing weeds growing in the ballast, a train is used composed of old engine tenders all connected together and filled with a 2 % solution of sodium chlorate. One of the tanks is then made to spray the liquid on the track; the train should be made to run regularly and systematically to obtain good results.

5. Then come the small operations in track maintenance such as boring sleepers, tightening and loosening coach-screws and fastening or unscrewing fish-bolt nuts, cleaning threads of bolts, cutting or drilling rails and illuminating site; these operations are done by appliances which are worked electrically and on the site. The power is produced from a portable generator which is composed of an internal combustion engine of 8 H.P. and a dynamo 2-4 kw., figure 17 of Dr. Müller's report. Price : 5 000 to 6 600 Rm.

An example of working these tools in boring sleepers and tightening coach-screws can be seen on pages 1106 (fig. 18) and 1107, figures 19*a* and 19*b* of the *Bulletin* for March 1930; a photograph showing the saw cutting a rail can be seen in page 1113, figure 25 of the same number. Rail drilling is illustrated on page 1114, figure 26 of the same *Bulletin*.

It is worth while mentioning that in the operation of thightening screws, when the screw is driven completely, the current is automatically cut off to avoid any mishap to workmen; the economy resulting from the use of such appliances is estimated as up to 36 %.

6. As regards loading and unloading of rails, the appliance used is a crane which is to be mounted firmly on a truck. Figures 6*a*, 6*b* and 6*c*, page 1091, of the *Bulletin* of March 1930 show the cranes fixed and in the working position. They are handy as they do not

(1) For the sake of convenience, these figures (2*b* excluded), and also all those mentioned hereafter and which appeared in the report drawn up by Dr. Müller for the Madrid Congress, will be reproduced in the present report (*Editorial*).

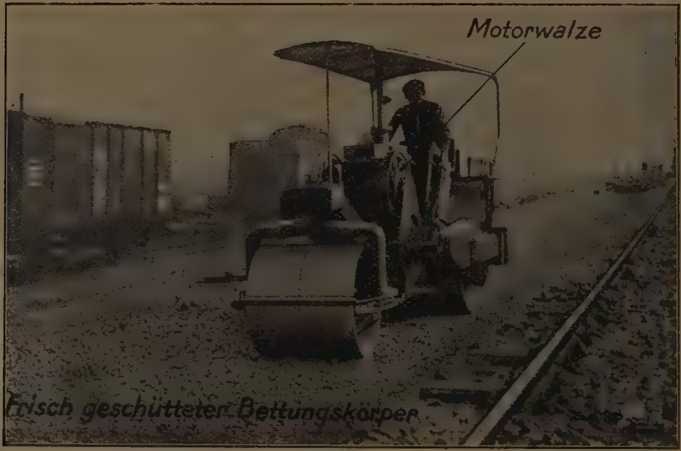


Fig. 1. — Motor roller rolling down freshly laid ballast.

Explanation of German terms: *Motorwalze* = Motor roller. — Frischgeschütteter Bettungskörper = Freshly laid ballast.

Fig. 2*a*. — Roller transportation wagon showing end opened.

block the neighbouring line when at work. An example is given of unloading a rail 30 m. (98 ft. 5 in.) long, for which 3 or 4 of these cranes are needed; for their erection and fitting to the truck 4 men are employed; they do it in a few

Fig. 3*a*. — Three-wheeled motor roller. — Flange wheels being removed.

Fig. 3*b*. — Three-wheeled motor roller. — Flange wheels being refixed.

Fig. 4*a*. — Self-discharging ballast wagons. — Loaded ballast train.

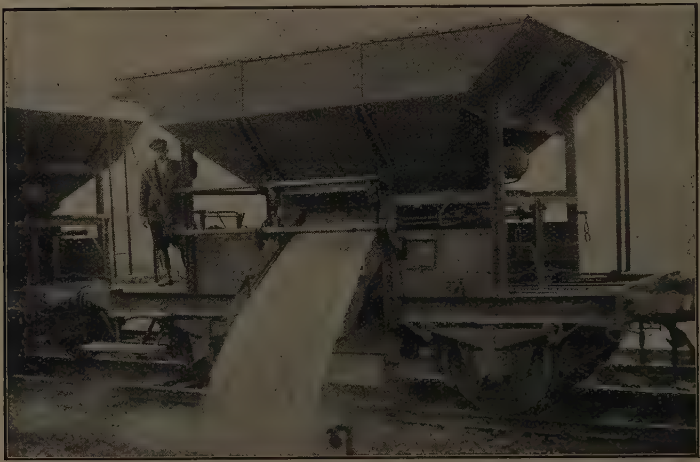


Fig. 4*b*. — Self-discharging ballast wagons. — Upper shoot opened.

minutes. Then each of these appliances is to be worked by two men.

Another advantage of this appliance besides economy, is that unloading of rails is made easy and that the latter keep straight, *i. e.* the small kinks that appear in rails thrown off the wagons and which are never got rid of, are avoided.

The price of a rail loading device is 325 Rm.

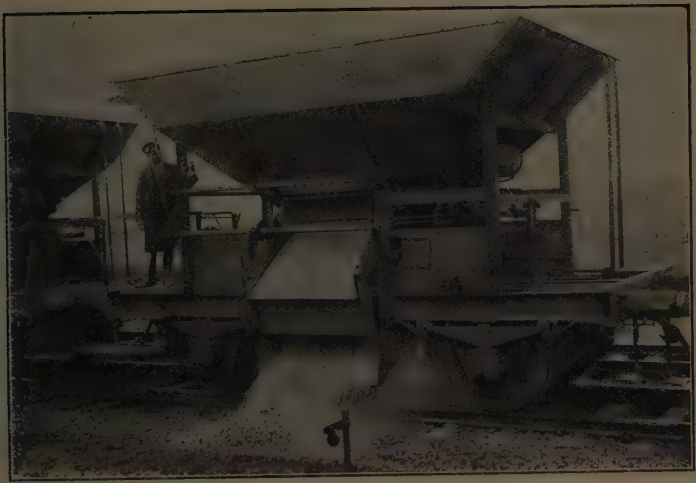


Fig. 4c. — Self-discharging ballast wagons. — Lower shoot opened.

Fig. 5a. — Loaded tipping wagons.

Fig. 5b. — Tipping wagon in the tipped position.

7. *Tracklaying machines :*

Originally a slowing crane made by Mohr & Federhaff of Mannheim was introduced but was abandoned owing to the fact that its use necessitates the closure of the neighbouring track and that it fouled the loading gauge. Views of same were shown by figures 9*a* and 9*b* of Dr. Müller's report page 1094 of the March 1930 *Bulletin*. Price : 38 000 Rm.

Then the Hook type was used, see figures 10*a* and 10*b*, page 1095 of the same *Bulletin*. This appliance has the disadvantage that it can be used from one end only. Price 33 000 Rm.

To overcome the above mentioned inconvenience the Niemag type was introduced which is symmetrically built and can be used from both ends; its price is 33 000 Rm. See figures 11*b*, page 1096, and 11*c*, page 1097, of the same *Bulletin*. This wagon is driven by a Diesel motor of 28 H. P. and can run by its own power at a speed of 9 km. (5.6 miles) per hour.

Also in 1925 the Neddermeyer tracklayer was adopted; it is a simple appliance consisting of two movable cranes on a frame, and these run on light rails laid outside the sleepers; it is worked manually. The new track to be laid is brought up on special wagons pulled by a motor trolley of 45 H. P. The assembled track lengths that may be carried by the wagons are 60 m. (196 feet) long.

This method is easy and handy and can be used without fouling the neighbouring line; it can be used in tunnels and on bridges without difficulty.

For carrying turnouts completely assembled and laying same, a method is shown by figures 13*a* and 13*b*, page 1101 of the same *Bulletin*. The appliance is a framework moving on rollers, and from it is suspended the turnout or crossing.

It is reported also that a new type of crane is under construction but its description or other information concerning it is not available.

Fig. 6*a*. — Rail unloading device.
Fixing the jib.

Fig. 6*b*. — Rail unloading device.
Fixing the crane post on to the wagon.

Fig. 6*c*. — Rail unloading device in operation.

Fig. 9a. — Slewing crane, Mohr and Federhaff type.

Fig. 9b. — Unloading rails with the slewing crane.

Fig. 10*a*. — Hoch tracklayer at work.

Fig. 10*b*. — Hoch tracklayer. — Taking a section of track from the wagon.

Fig. 11*b*. — Niemag tracklayer. — Tak'ng a section of track from the wagon.

Fig. 11*c*. — Niemag tracklayer. — Laying down a section of track.

8. *Packing under sleepers.*

The mechanical appliance used is a pneumatic one; the power is provided by an internal combustion engine which is brought to the site and left lying outside the loading gauge. This machine controls an air pump which drives the pis-

Fig. 13*a*. — Switch laying apparatus (side view).

Fig. 13*b*. — Switch laying apparatus (front view).

ton of the packing tool to and fro at a great speed.

The packing tool used varies in size according to the kind of ballast; for broken stone it is smaller and for gravel it is larger.

The tamping machine should not be used in loose ballast nor in hard (concrete-like) ballast; in the case of loose ballast, it should first be packed manually and then completed by the packing tool.

Sleepers of the double-track lines are to be packed only on one side against the direction of travel, but the double sleepers under joints and broad sleepers are to be packed on both sides. Owing to the great noise set up by this machine, it is forbidden to make use of it in foggy weather or snow storms. This machine is economical if used continuously; its price is 3 300 Rm. See figures 21, 22*a*, *b* and *c* and 23, pages 1109, 1110 and 1112, of Dr. Müller's report, *Bulletin* for March 1930.

9. *Removal of snow.*

For this a snow plough or rotary snow plough is used.

10. *Distribution of small materials alongside the line.*

Small trolleys driven by an internal combustion engine are used satisfactorily for comparatively long distances; these trolleys carry from 3 to 5 tons and can, with this load run at a spead of 15 to 30 km. (9.3 to 18.6 miles) per hour on level track. The price is 8 000 Rm. (See figs. 14*a*, 14*b* and 14*c*, page 1102 of the *Bulletin* for March 1930.) For smaller distances a one-wheeled trolley is used (see figs. 15*a* and 15*b*, page 1104 of the same *Bulletin*); this trolley can be pushed, put on the rail or taken off by one man; its price is 90 Rm.

11. *Transport of supervisory staff and men.*

For this a motor car-like trolley is used, but only by divisional superintendents (see fig. 27, page 1114 of the March 1930 *Bulletin*); for the district officers a smaller trolley is used (see figs. 28 and 29, page 1115 of the same *Bulletin*).

12. *Track testing machine.*

For this purpose use is made of a car, the weight of which is 60 tons, and by means of apparatus contained in it the following defects are automatically and graphically shown :

1. deflection at rail joints;
2. width of gauge;
3. relative height of both rails;
4. alignment of track specially in curves.

In addition to this, the speed and distance are also recorded.

The main lines are tested by this car twice a year and branch lines only once a year.

Bulgaria.

State Railways.

Replied in stating that they use mechanical appliances for crushing ballast, and special wagons for loading and unloading ballast (Talbot system). Motor driven appliances for tightening coachscrews, and snow ploughs to clear the track from heavy snow are also in use. Inspection motor trolleys for the use of the chief of the section are also employed.

The appliances used are of well-known types, most of them being of American and German make.

The price of the stone crushing machine is 656 250 leva and that of a ballast wagon 409 337 leva; the snow plough costs 111 500 Rm. and the coachscrew tightening machine, 980 dollars.

The Bulgarian State Railways also state that all these machines have not been long in service, and for this reason they were unable to report fully on their usefulness.

Fig. 14a. — Standard gauge motor driven trolley with internal combustion motor. View with sides fitted on.

Fig. 14b. — Standard gauge motor driven trolley. — View without sides fitted.

Fig. 14c. — Standard gauge motor driven trolley. Arrangement of the motor under the platform.

Fig. 15*a*. — Single rail trolley in use.

Fig. 15*b*. — Single rail trolley being tipped

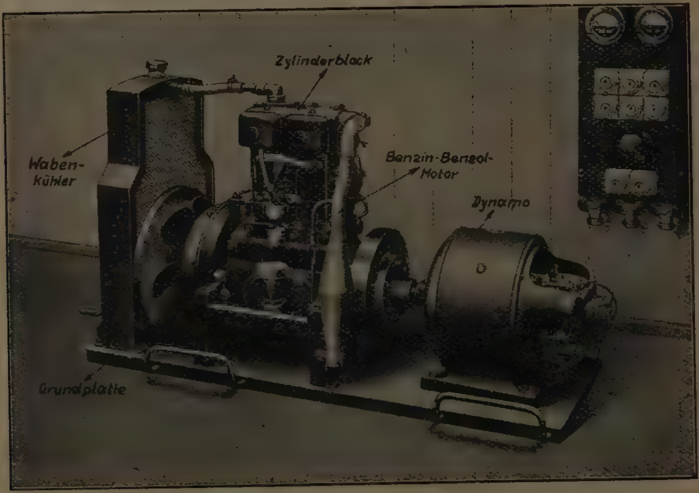


Fig. 17. — Portable generating set.
(Internal combustion engine coupled to direct-current dynamo).

Explanation of German terms: Grundplatte = Baseplate. — Wabenkühler = Radiator.

Fig. 18. — Sleeper boring machine in operation.

Fig. 19a. — Hand tools connected to a generating set at work on the track.

Fig. 19b. — The same tools at work at the depot.

Egypt.

State Railways.

Replied in stating that they use mechanical appliances for :

1. adzing and boring sleepers;
2. track testing, and
3. conveying high officials (motor trolleys).

The adzing and boring machine, a photograph of which appeared on page 1036 of the March 1930 monthly *Bulletin of the International Railway Congress Association* (1) and is reproduced hereafter, costs £ E. 1 650 and is made by Messrs. T. Robinson & Son, England; it is driven by steam and is stabled under a roof.

This machine can adze and bore 6 holes at a time in each sleeper and can finish 1 200 sleepers in 8 hours. The cost is only 1/6 of that of hand labour.

This machine has been in use for many years and proved very satisfactory.

The track testing machine is of Hallade patent and costs £ E. 125.

The apparatus is carried in a bogie coach and on the bogie; it automatically and graphically shows defects at the joints and in the gauge and alignment. It also records the time and distance.

(1) Report on question IV, Madrid Congress, drawn up by Mr. Hauer.

Greece.

State Railways. — Replied briefly stating that all track maintenance and renewal is carried out manually.

North Western Railways. — No reply was received.

Thessaly Railway. — No reply was received.

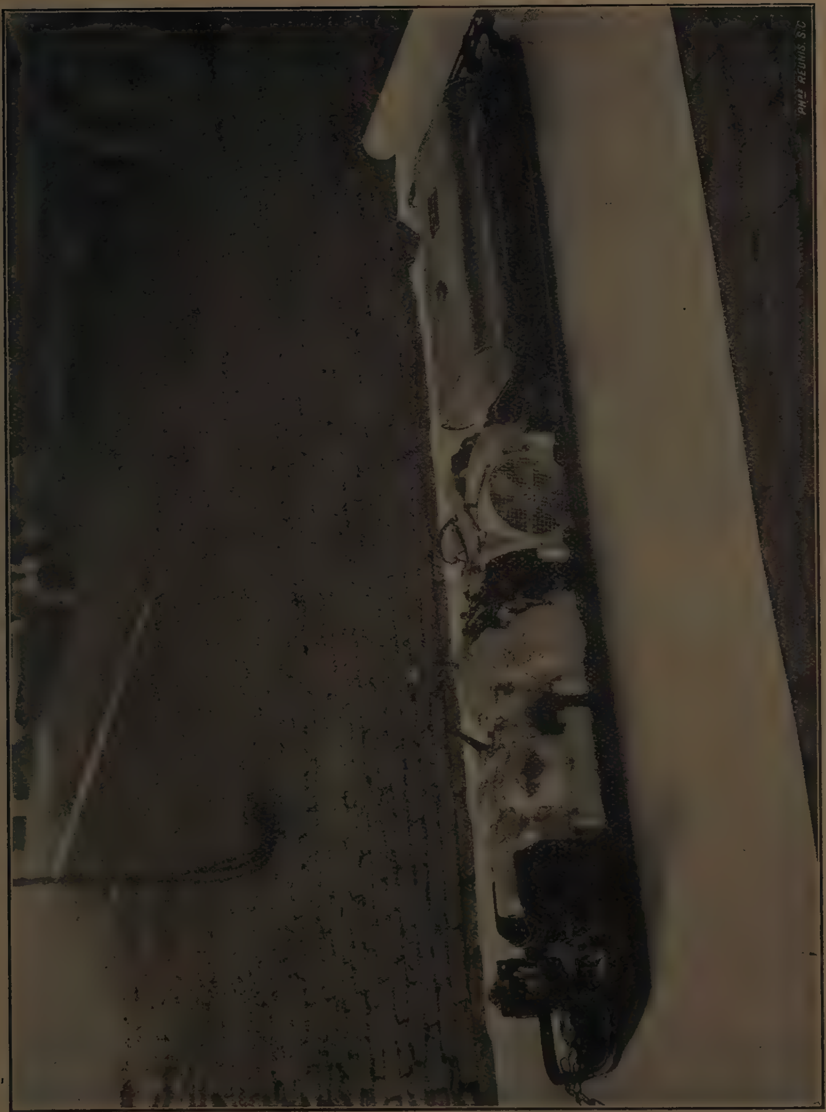


Fig. 21. — Track tamping machine.

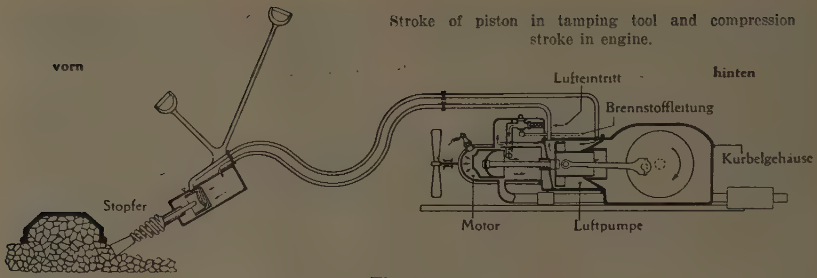


Fig. 22*a*.

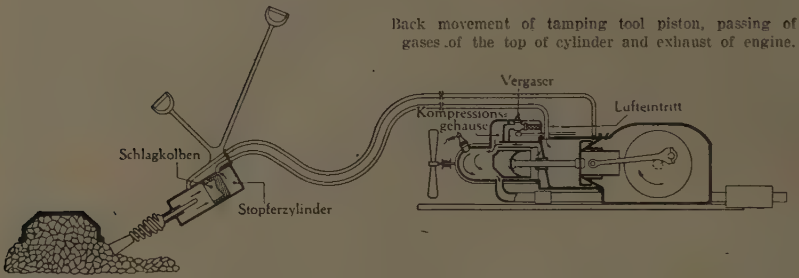


Fig. 22*b*.

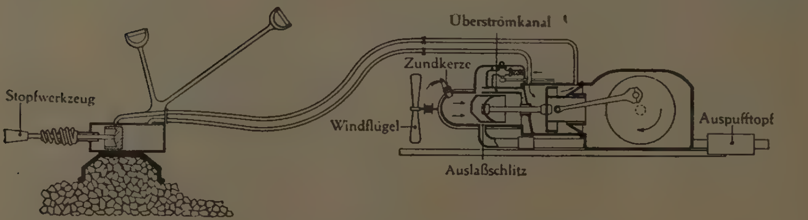


Fig. 22. — Diagram of operations of tamping machine.

Explanation of German terms in figs. 22 a, b, c : Auslass-Schlitz = Exhaust port. — Auspufftopf = Silencer. — Brennstoffleitung = Fuel pipe. — Hinten = Back. — Kompressionsgehäuse = Compression chamber. — Kurbelgehäuse = Crankshaft housing. — Lufteintritt = Air inlet. — Luftpumpe = Air pump. — Motor = Motor. — Schlagkolben = Piston. — Stopfer = Tamper. — Stopfwerkzeug = Tamping tool. — Stopferzylinder = Cylinder. — Vergaser = Carburettor. — Vorn = Front. — Überströmkanal = Transfer port. — Windflügel = Air fan.

Fig. 23. — Krupp tamping machine at work.

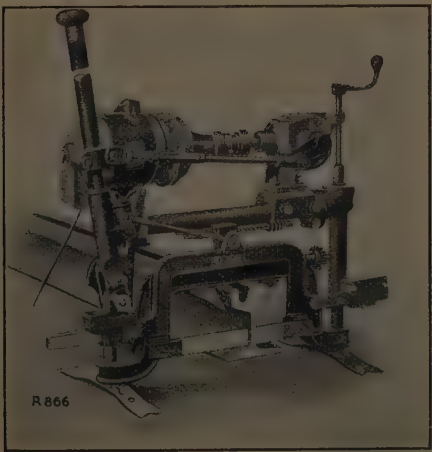


Fig. 25. — Electrically driven rail saw.

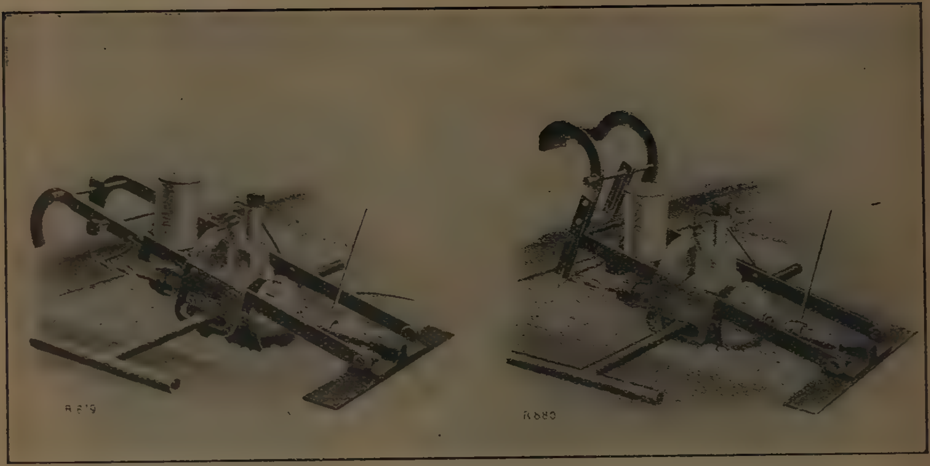


Fig. 26. — Electric rail drilling machine.

Fig. 27. — Six-seater rail motor car.

Fig. 28. — Motor-driven trolley with trailer for inspection staff.

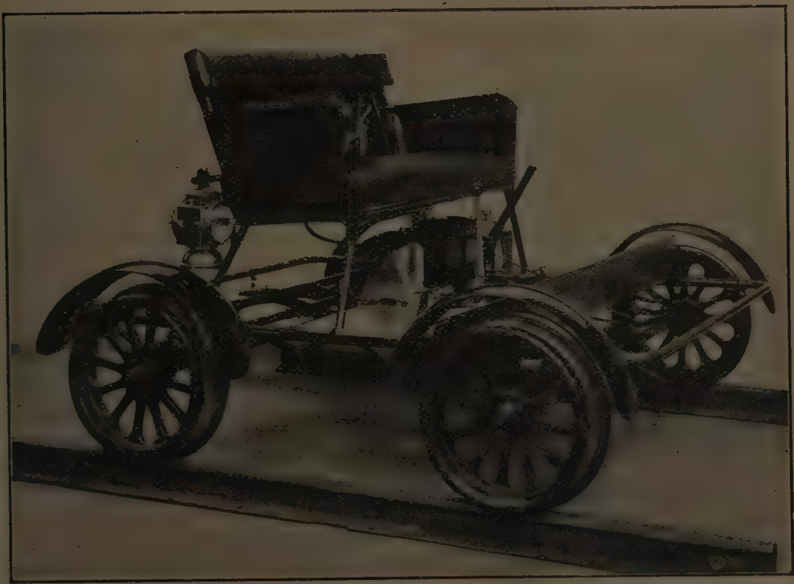
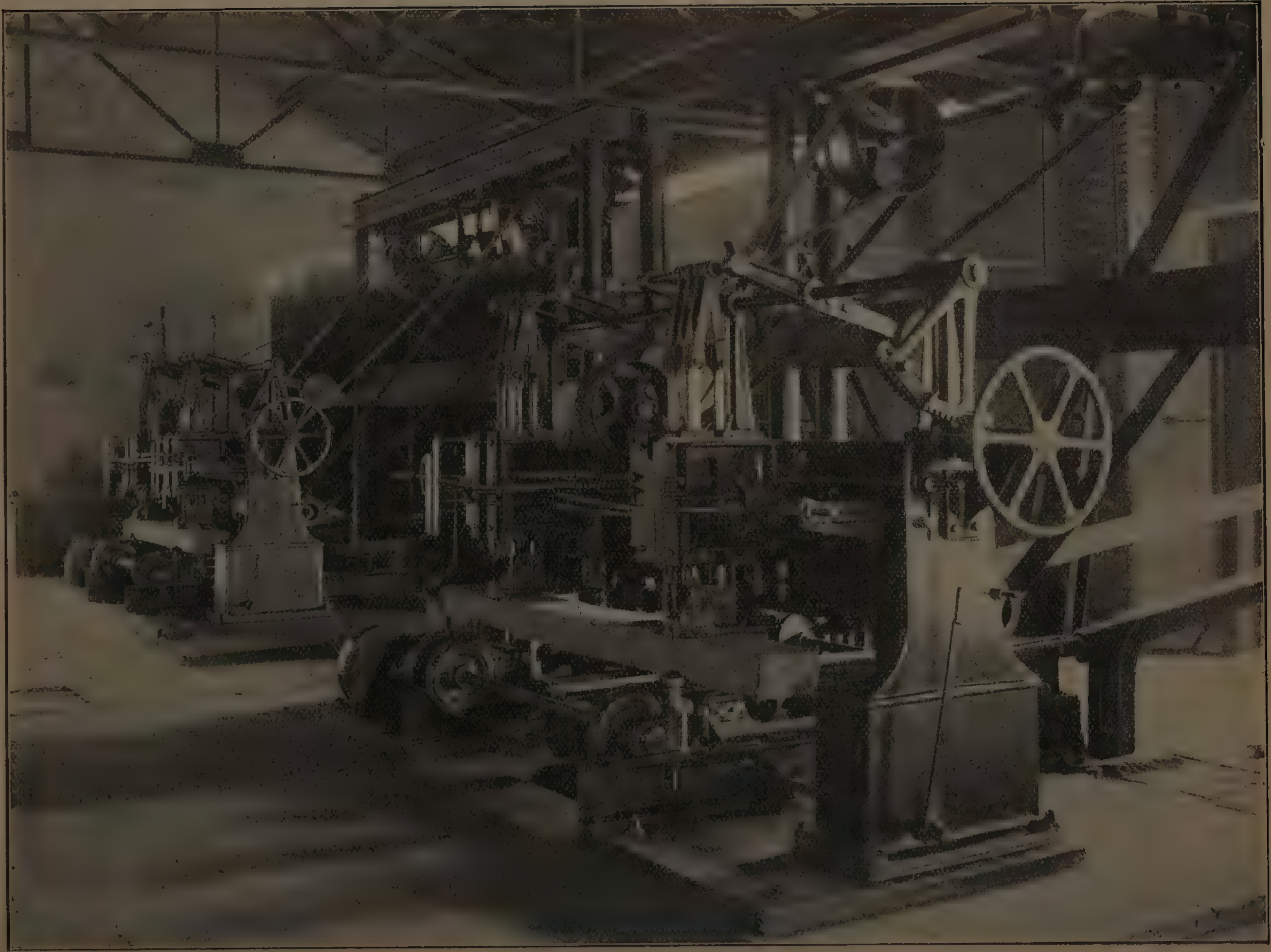


Fig. 29. — 2-seater motor-driven trolley for the permanent way inspector.



Machine for adzing and drilling sleepers, Egyptian State Railways.

Pelopennesus Railway. — Replied briefly that they do all work by hand except crushing stone to provide ballast. They also employ sometimes special wagons for carrying ballast; but no description was given in either of these cases.

Poland.

State Railways. — No reply was received.

Rumania.

State Railways. — Mechanical appliances are used for the following operations :

a) Boring sleepers;

b) Drilling rails;

c) Cutting rails;

d) Tightening coachscrews;

e) Clearing track from snow;

f) Carrying employees inspecting the lines;

g) Track testing machines.

The appliances used for the first four operations are of German make — Robel (Munich) — and are electrically driven. The power is provided by the portable generator, a photograph of which is shown in the catalogue of the said firm (Robel), page 1, figure R.10; its price is 4 950 Rm. This machine supplies the electric current which drives the various tools used in the four different operations mentioned above.

A photograph of the tool used for boring sleepers is shown in the same catalogue, page 12, figure R.3; price: 285 Rm.

Figure R.9, page 9 of the catalogue shows the rail cutting device, which costs 1 125 Rm., and figure R.22, page 9, the tool used for drilling holes in rails, the price of which is 625 Rm.

Finally, the screw tightening machine (price 1 125 Rm.) is shown on page 5, figure R.6 of the same catalogue.

It is also stated that these machines and tools have given very satisfactory results as regards the accuracy and the speed with which the work is done with them.

But it is very difficult to make an exact comparison with the hand tools, from an economical point of view as these appliances have only been introduced a year or two ago. However, it may be said from now that large savings will result from their use.

It is also stated that the machines are so made that a simple labourer can make use of them after a short period of training.

The machines are mainly used for track relaying and also in the ordinary maintenance work.

For clearing the track from snow, the Rumanian State Railways bought, in 1897, an American machine from Messrs. Cooke Paterson & Co., costing at that time 90 000 francs.

In 1907 they bought a second machine (Wiener-Neustadt) at a cost of 88 000 francs.

The characteristics of the machines are the following :

2 bogies at a distance of 4.720 m. (15 ft. 6 in.) from centre to centre;

Total length 10.815 m. (35 ft. 6 in.);

Total weight 30 tons.

In 1929 a Swedish machine was bought (104 000 Swedish crowns) supplied by Messrs. Nydqwist & Holm of Trollhättan (Sweden).

The characteristics of this machine are the following :

2 bogies at a distance of 5.350 m. (17 ft. 7 in.) from centre to centre;

Total length 19.630 m. (64 ft. 5 in.);

Total weight 16 tons.

The use of these machines is restricted; they are only employed when hand labour cannot possibly be used.

No description was given of machines used for transporting men, nor of track testing machines.

Operations in track maintenance renewal for which mechanic

Note : (Yes) opposite any operat

Description of work.	*German State Railway Co.*	*Bulgarian State Raiways.*	*Egyptian State Railways.*	G R	
				State Railways.	*North Western Railway.*
Formation.					
Cleaning side ditches	No.	No.	No.	...	...
Maintaining side slopes	No.	No.	No.	...	...
Consolidating new earthfillings . .	Yes.	No.	No.	...	...
Ballast.					
Breaking ballast.	...	Yes.	...	...	...
Loading and unloading	Yes.	Yes.	No.	...	...
Transportation	Yes.	Yes.	No.	...	...
Cleaning for permeability	No.	No.	No.	...	...
Consolidating inferior layer. . . .	Yes.	No.	No.	...	...
Weeding	Yes.	Yes.	No.	...	...
Sleepers.					
Adzing and boring	Yes.	No.	Yes.	...	...
Loading and unloading	...	No.	No.	...	...
Taking up old and replacing by new.	...	No.	No.	...	...
Rails.					
Loading and unloading	Yes.	No.	No.	...	...
Bending, if any	...	No.	No.	...	...
Cutting	Yes.	No.	No.	...	...
Drilling	Yes.	No.	No.	...	...
Straightening	...	No.	No.	...	...
Taking up old and laying new. . .	...	No.	No.	...	...
For renewing complete track lengths.					
Taking up completely assembled track lengths.	Yes.	No.	No.	...	...
Unloading and laying completely assembled track lengths.	Yes.	No.	No.	...	...
Tightening coachscrews	Yes.	Yes.	No.	...	...
Tightening fishplate nuts.	Yes.	Yes.	No.	...	...
Raising track to desired level . . .	No.	No.	No.	...	...
Packing ballast	Yes.	No.	No.	...	...
Turnouts.					
Loading and unloading	Yes.	No.	No.	...	...
Laying	Yes.	No.	No.	...	...
Station yards.					
Cleaning	No.	No.	No.	...	...
Removal of snow from track . . .	Yes.	Yes.	...	...	...
Removal of sand from track . . .	...	...	No.	...	...
Distribution of small material. . .	Yes.	No.	No.	...	...
Conveyance of inspectors and men. .	Yes.	Yes.	Yes.	...	...
Track testing machine.	Yes.	No.	Yes.	...	...

...ances are used by the various Railway Administrations

...that mechanical means are employed.

...E		Polish State Railways.	Rumanian State Railways.	Czechoslovakian State Railways.	TURKEY		Jugoslav State Railways.
...essaly ...ilways.	Peloponnesus Railway.				State Railways.	Smyrna-Cassaba Railway.	
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No	No.
...	No.	...	No.	...	No.	No.	No.
...	Yes.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	Yes.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	Yes.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	Yes.	...	No.	No.	No.
...	No.	...	Yes.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	...	...	No.	...	No.	No.	No.
...	...	...	No.	...	No.	No.	No.
...	...	...	Yes.	...	No.	No.	No.
...	...	...	No.	...	No.	No.	No.
...	...	...	No.	...	No.	No.	No.
...	...	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	No.	No.	No.
...	No.	...	No.	...	Yes.	Yes.	Yes.
...	...	...	...	...	...	...	...
...	No.	...	No.	...	No.	No.	No.
...	No.	...	Yes.	...	No.	No.	No.
...	No.	...	Yes.	...	No.	No.	No.

Czechoslovakia.

State Railways. — No reply was received.

Turkey.

State Railways. — In their reply they mentioned that mechanical appliances are used only for removing snow from the track. The machine is a rotary snow plough.

Smyrna-Cassaba Railway. — Replied that mechanical appliances are used for clearing track from snow. The machine used costs 60 000 fr. and is pushed by an engine. Comparing it with hand labour and under the same conditions, it saves 75 %; but the machine cannot be used in all cases. Generally speaking snow should be fresh or not absolutely solidified to enable the machine to work.

It is stated also that experience is needed to work this machine and that it is not possible to make it work in cuttings with steep slopes, in long cuttings or in cutting on sharp curves.

Jugoslavia.

State Railways. — Replied that mechanical appliances are not, in general, looked upon with great favour, stating that this was a consequence of the war and that the idea is to relieve unemployment. However cutting weeds off the line mechanically was done by means of a Swiss machine as a trial. Although by going over the line once it did cut the weeds, rendered ballast permeable and arranged it to the standard section, yet the result was not satisfactory from the point of view of economy.

For work such as boring and adzing sleepers and for cutting and drilling same, Robel tools are used.

For removing snow, snow ploughs are sometimes used.

Summary.

13 Administrations received a questionnaire to which only 8 replied.

In order to summarise the replies of the various Railway Administrations, the table, pp. 978-979 was designed showing in the first column the various operations that are to be carried out in track maintenance work and renewals; opsite to each operation is indicated by the words *Yes* or *No* whether mechanical appliances are used or not.

A. — As regards the maintenance of earthwork, no mechanical appliances are used, except for consolidating newly filled earth, on the German State Railways.

B. — For ballast work, 1 Administration uses stone crushing machines to produce ballast; 3 Administrations use special self-discharging wagons for ballast transportation; only 1 Administration uses a roller for consolidating the inferior layer.

For killing weeds by chemical process, the German State Railway Company uses sodium chlorate, the Bulgarian State Railways have only tested the method.

C. — For adzing and boring sleepers three Administrations use mechanical appliances. The German State Railway Company generally prepares the sleepers in a special yard and very often where the sleepers are treated. The Rumanian State Railways use Robel electrically driven boring machines. The Egyptian State Railways have a special shop to do this work and the machine, which is stationary, is driven by steam.

D. — *Rails.* — For loading and unloading rails the German State Railway Company uses mechanical appliances.

For cutting rails and drilling holes in same two Administrations use mechanical appliances.

For packing ballast under sleepers only one Administration uses mechanical means; it is a pneumatic hammer controlled by an air pump which is driven by an engine worked by benzol or crude oil. The whole lot is portable.

E. — For laying in and taking out completely assembled track lengths, only one Railway Administration employs mechanical appliances.

For other small maintenance works of which there is a great deal to do, such as tightening coach screws and fishbolt nuts, 3 Administrations use mechanical appliances electrically driven, source of power being a portable generating set.

F. — For loading and unloading turn-outs only one Administration uses mechanical appliances.

G. — As regards cleaning station yards no mechanical appliances have ever been used or tried.

H. — For removing snow from the track, all Administrations use the snow ploughs. The Egyptian State Railways are not troubled with snow.

I. — For removing sand, the Egyptian State Railways, who alone suffer from this inconvenience make use of manual labour.

J. — For distributing materials, only one Administration uses mechanical means (for transporting materials a long distance). The vehicle is driven by an internal combustion engine, and carries from 3 to 5 tons of materials.

K. — For conveyance of inspectors and men, 6 Administrations use motor trolleys for high officials; the German State Railway Company use moreover motor trolleys for district officers.

L. — Track testing machines : 3 Administrations use a special machine for this. The German State Railway Company has a special car weighing 60 tons. The Egyptian State Railways carry the apparatus on the bogie of a coach.

Conclusions.

From the replies received from the various Administrations may be deduced that since the last Congress, held in Madrid in 1930, some progress is revealed in the use of mechanical appliances for track maintenance and renewal.

Snow ploughs and motor trolleys are used nearly everywhere.

Mechanical appliances are getting used more and more for the following operations :

1. Transportation of ballast by special self-discharging wagons;

2. Tightening and untightening screws and fishbolt nuts;

3. Packing ballast under sleepers.

The advantages gained from an economic point of view are considerable, reaching 50 % if used in renewing lines or in ordinary maintenance work, provided the machines are used for a long period and systematically.

In addition to this economic advantage : *a*) time is saved, and *b*) the work is more accurate.

Besides the above mentioned operations there are some Administrations where other work, such as adzing and boring sleepers, cutting or drilling rails, are done mechanically and with satisfactorily economic results.

Germany does nearly all her work mechanically, and also kills weeds chemically.

The writer believes that it is most likely due to the great cheapness of hand labour, that mechanical appliances do not make headway in many a country, especially in the East.

During the present prevailing financial crisis, some Governments have recommended the employment of hand labour as much as possible in order to relieve unemployment and for internal economy.

[621. 138]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

XIIth SESSION (CAIRO, 1933).

QUESTION IV:

Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

REPORT No 2.

(Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland),

by E. STUDENT,

Reichsbahndirektor, Mitglied der Hauptverwaltung, Deutsche Reichsbahn Gesellschaft
(German State Railway Company).

CONTENTS.

Preliminary observations.

In order that this question should be dealth with along similar lines, Mr. Klatovsky, of Prague, has prepared a questionnaire, which after comparatively minor alterations, forms the basis of my paper. It divides the material into six sections and deals with answers under maintenance, design and materials, operation and general measures.

The answers from the Administrations concerned are attached to the report in the appendix. All the conclusions which bear on an increase of engine mileage between two heavy repairs and satisfactory engine economy have been abstracted from the six sections and appear in the report itself. The matter presented cannot be dealt with without regard to the question of economy, as it must always be the aim to obtain from the engine the maximum service with the minimum expenditure per unit of work done.

QUESTIONNAIRE.

I. — *General repairs.*

1. On what does the necessity for a general repair depend ?
2. Are legal ordinances in existence calling for inspection and testing of the locomotive boiler, the vehicle, the brake, etc. ?
3. Are these examinations carried out after a fixed period or after a given mileage ?
4. Do the times and mileages vary in accordance with the class of engine (passenger, goods and shunting engines) ?
5. How is the boiler examination carried out ? Is there differentiation between internal and external examination ?
6. What work is carried out on the boilers on these occasions in accordance with a schedule ?

II. — *Periodical examinations.*

1. What regular work is done on the engine in service ? This refers to periodical examination of steam pistons and valves, brake, rod bearings, etc. If special schedules exist they should be attached.
2. How much do these regular examinations contribute, in your opinion, towards increasing the mileage between two general repairs, and how far does the discovery of flaws and worn out parts tend to prevent failures ?
3. What repairs to engines in service are undertaken in the running shed repair shops ?
4. Do the enginemen assist ?
5. Are special gangs of fitters provided for day and for night duty ?
6. How are the numbers of workers required, arrived at ?
7. Do they work on contract or day wages.

III. — *Light repairs.*

In order to increase the engine mileage between two general repairs, tyres must be turned in the interval and on occasion they must be renewed; the axle bearings are then generally overhauled.

1. When engines are lifted, are pistons, valves, regulator, etc., examined ?
2. Where is such work carried out — in the running repair shops, or in the main shops ?
3. How much time is occupied by a light repair, during which tyres are re-turned or renewed and other work is carried out ?
4. How much do such light repairs tend to raise the mileage run between two general repairs ?
5. What is the practice when an engine has to be lifted for repair within 6 or 9 months of a periodical boiler inspection and when experience shows that the engine will not be run down before that inspection, after the engine has been lifted and repaired ?
6. Are special orders or requirements in force with regard to bogies or carrying axles ?
7. Is it customary on your system, when an engine is lifted, to change the leading wheels, which are most liable to wear, so as to obtain a better utilization of the complete set of wheels ?
8. The light repairs and lifting should for instance be undertaken every three years. As a matter of fact engines, according to their condition do not run for the three years, but must be withdrawn for light repairs at the end of two years. The light repairs, which deal chiefly with the running gear, should make

it possible to postpone the periodical general repair till the expiry of the three years. It might also be possible by these means to extend the period between such repairs to four years.

9. In your opinion, which are the engine parts which have the most influence upon obtaining increased mileage ?

IV. — *Materials, design, etc.*

1. What specifications exist in your case covering tyre and rail material ?
2. How should these be dealt with so as to give the best results in service?
3. Have you already undertaken investigations or tests in this direction ?
4. To what thickness do you run your tyres ? A sketch showing the section of a new tyre should be attached.
5. Have you made trials in order to determine the best tyre profile to obtain the highest possible mileage?
6. What design of stuffing box have you found to be most suitable for superheated engines in order to work with the lowest cost and the least work ?
7. What bearing metal do you employ in rod and axle bearings ? What is the composition of the alloy ?
8. Does bad feed water affect the mileage between two heavy repairs ? What action do you take to improve matters ?
9. What kind of oil and what oiling arrangements do you employ :
   a) For cylinder lubrication ?
   b) For lubricating axles and rod bearings ?
10. Is mechanical lubrication generally in use ?
11. What advantages are obtained from such lubrication ?
12. Do you lubricate either the flanges of your wheels or the rails on curves, in order to reduce tyre wear ?
13. Does such wear occur generally or only on specially bad sections ?
14. What is your experience in respect to this ?

V. — *Operation.*

1. How are your engines manned ? Single, double or treble sets of men?
2. Which is the commonest arrangement ?
3. Where do you work with three sets of men ?
4. What is your experience with the multiple crew system ?
5. What is the highest mileage obtained on one unbroken turn of duty ?
6. What limit do you place on your engine runs and how are they fixed?
7. How far do you consider the engine men in fixing the limits ?
8. How far does the quality of the coal, the size of the grate, the capacity of the ashpan and mechanical stoking affect matters ?
9. What conditions commonly obtain as regards consumption per square metre of grate area and evaporation per square metre of heating surface ?
10. What average and maximum mileages are run in express, passenger and goods services, by engines between two general repairs ? It is requested that a few typical duty sheets should be sent to the reporter, covering the above classes of service as well as some relating to shunting turns.
11. What time is allowed to the driver and fireman to prepare their engine ?
12. Have you any special arrangements for cleaning fires when using inferior coal ?

13. Have you taken any steps with a view to raising the daily mileage of your engines? If so what are they and what has been the result?

14. Do you pay premiums for high engine mileage?

15. What class of employees receive these premiums?

16. In your experience, what influence has a high degree of cleanliness of the engine on the detection of incipient defects, leaks, etc., and the subsequent avoidance of serious defects and costs resulting therefrom?

17. Has the psychological effect on the staff been estimated?

18. Does a probable increase in mileage run justify a small increase on low cleaning costs?

VI. — *General.*

1. Have changes or improvements in the construction of the engine or boiler or changes in operation made lately, led to the raising of the mileage run by engines between two repairs? If so specify them.

2. The reporter desires in particular, information as to the treatment of the axle and rod bearings in service, and in connection with their periodical repair.

3. How are the journals of the driving and coupled wheels, crank pins, and the straight and crank axles dealt with? Are they tested at regular intervals for circularity, and reground?

4. How is the casting, machining and fitting of bearings carried out?

REPORT.

I. — General repairs.

General repairs will usually be carried out in accordance with the general condition of the engine. The condition of the tyres and tubes governs this time. Generally the tyres are re-turned once and not infrequently twice, before the boiler, frame and driving gear are so far worn out that safety and economy call for a general overhaul of the whole engine. With good or average feed water the majority of the tubes will last until the engine as a whole is so far worn that a general repair is required, and it may then be that the boiler has suffered permanent damage.

Boiler inspections are partly governed by State laws and partly by the rules laid down for the purpose by the railway companies.

Inspections may be divided into:

a) Those that are undertaken periodically, in point of time (external and internal);

b) Those that are undertaken after a given mileage has been run;

c) Such as are carried out at each general repair.

In the case of new boilers, the first internal examination takes place on the different railways after 9 years, 8 years and 4 months, or 7 years, and it is repeated after 6 years or 6 years and 3 months. The periods between external examinations vary between 4 and 3 years. The Danish State Railways only carry out internal examinations at 4-year intervals. Some lines carry out a pressure test after each heavy repair and this replaces the boiler examination. Tubes and fireboxes are renewed as required. In the case of 5 Administrations, an internal examination is carried out after a definite mileage has been run.

The work carried out at an internal examination is generally the same under all administrations, and there is little difference in the case of external examination; the boiler lagging is, however, removed in all cases. The test pressures used vary. They are usually from 3 to 5 kgr./cm² (43 to 71 lb. per sq. inch)

higher than the working pressures ; in the case of one company the test pressure is required to exceed the working pressure by over 50 % and it must not be less than 14 kg./cm^2 (199 lb. per sq. inch).

Only the German State Railways, and the Dutch Indies and Danish State Railways call for periodical inspections of the frame and tender. The remaining administrations have no such requirements. In these cases the general repair is considered as replacing this examination. Periodical brake examination is only carried out by the German State Railways.

Systematic examinations of the boiler are in the first place safeguards, but — granted always careful workmanship — they prevent interruptions of service due to leakages and tube failures. The test pressure should not be too much above the working pressure, as where boilers work at high pressures, such as 16 atm. (227.5 lb. per sq. inch) the material can, under certain circumstances, be so highly stressed, that damage may be started, which cannot be detected by the pressure test, but may appear in service at a later date. In addition to the cold water test, a steam pressure test is also required to show up any want of tightness.

In the case of the German State Railways, when the frame and tender are examined, the frame is carefully gauged over and together with the driving gear are brought up to their original condition so that when the engine leaves the shops it can be taken as being in as new condition. It may be stated that the newer express locomotives have run from 350 000 to 400 000 km. (217 500 to 248 500 miles) between two general repairs. In order to cheapen maintenance, it is intended to increase the period between the examinations of frames and tender to 4 years or to undertake careful gauging and bringing up to original condition only at such time as the boiler is examined. It is possible that a recommendation will be made to drop the external boiler examination and to carry out the internal examination every 4 to 6 years, as after this time, depending on the work done by the engine, the work to be done to the boiler continually increases.

The examination of the compressed air brake of the locomotive makes in the first place for safety in working. When the brake is working properly, the train starts away easily, and, given proper operation of the regulator and valve gear, acceleration is improved and slipping is prevented, and the axles and driving gear are thereby preserved.

Periodical examinations based on time are more valuable than those based on mileage. The examinations generally take place at longer intervals and are repeated systematically and therefore make for greater safety. In the case of lines where examinations are made after a predetermined mileage, the mileage is, where there are sections with light traffic, only reached at very long intervals as compared with sections with heavy traffic, so that the periods at which boiler inspections take place may vary very considerably, in spite of the fact that dangerous corrosion increases more in accordance with time than with mileage. In such cases the mileage cannot be increased by careful handling whilst carrying out repairs like various circumstances also reduce the wear of the engine.

If the boiler examinations are regularly carried out at the same time as the general repairs, the engine will be withdrawn from traffic for a longer time at each general repair and the mileage will thus be reduced.

The examinations and general repairs must in any case be carried out carefully and properly if the engine is to run a high mileage in the interval. The main shops should be of ample size and equipped with modern machinery and a well

trained labour force is required. The main shops should therefore be well staffed and be provided with accurate machines, good gauging appliances and adequate supervision. The cost of this will all be returned in the high mileage run by the engines.

II. — Periodical examinations.

The same value is not everywhere attached to the examinations carried out periodically during the service life of the engine. The washing out of the boiler, which comes under this heading, and which in any case must be carried out, has not been specified by many lines, perhaps under the impression that it obviously has to be done and is not to be regarded as a periodical examination. It has however been overlooked that when washing out the boiler certain periodical work, such as attention to the boiler fittings, is necessary.

It is not possible to put into figures the extent to which systematic examinations prevent failures in service or accidents. Estimates can only be approximate.

On the majority of railways the running repair shops only take care of the smaller troubles caused by wear and tear or other similar causes.

The Norwegian State Railways have, unlike other railways, no main shops. In their case, general repairs are carried out in the running shed repair shops, with the exception of the internal boiler examination which is carried out in an existing central shop.

Generally the enginemen are not utilized for making running repairs, but the Dutch-Indies, the Finnish and the Norwegian State Railways are exceptions to this rule. On the last mentioned, however, the enginemen are only occasionally called upon for repair work. If this is also the case on the Danish lines, is not clear from the report. It may however be concluded from the answer to question 5, that on those lines the fireman carries out repairs.

Whether the minor running repairs are attended to by the enginemen is of small importance so long as the work is carefully and properly carried out. Generally speaking, if the men are employed on repair work, their mileage will be reduced if their shifts are not prolonged.

It may generally be accepted that on all railways the enginemen are expected at once to tighten up bearings, nuts, screws and wedges and to make good such small defects as may manifest themselves during a trip, so far as is possible with the means at their command.

Day work is in force in the majority of running shed repair works because supervision is easier, and because it is always more economical than night work. Certain lines maintain night fitters where necessary.

On the German State Railways and the Netherlands Railways, in order to ascertain the number of workers required for the upkeep of the running engines, tables are used which have been specially worked out for all classes of engine.

This method is generally recommended, as it is thus possible to suit the number of workers employed to the work to be done. After all it is preferable to employ one or two hands too many, than to have too few.

In the running repair shops of the majority of railway administrations, wages by the day or the hour are paid. The German State Railway Company has within the last 10 years changed over to contract work and believes that it works more cheaply on that system.

Contract work calls for more clerical work and is not easy to introduce in repair work because repair work differs very greatly and often cannot be estimated for correctly before the job is started. Control of the work is also necessary. On the other hand, contract work encourages the worker to greater

output and this, as experience has shown, leads to savings for the administration and higher earnings for the worker.

Day or hour work is simpler for running shed repair work, but calls for increased supervision if a satisfactory output is to be obtained.

If the work of the main shops, which is the necessary basis for the obtaining of good locomotive mileage, is to have results, it must be supplemented by the systematic and careful upkeep of the engines in service. To this end, the running repair shops must be equipped with the necessary machine tools and plant of satisfactory quality. These shops must also turn out work of the required accuracy, if the maximum mileage is to be got from the engines and the enginemen are to be considered. Old and worn out machine tools should be scrapped. No less important is the proper provision of staff. Only proper and punctual completion of the running repairs will produce satisfactory mileage and lead to true economy.

False economy in upkeep will lead to loss on actual values and working capital. The number of the engines in service will be increased and the bills for oil, coal, etc., will go up.

It is very generally recognised that the engine staff are an important factor as regards mileage obtained from the engines. On the German State Railways, the drivers put in defect tickets to the repair shops when defects are detected. These tickets are returned to the driver on the completion of the repairs and he enters on this ticket, before he returns it to the shops, the result of the tests during the trip. The driver is thus linked up with the repair process. Since the defect tickets are closely connected with the contract system in the repair shops and represent a certain money value, they cannot be neglected or mislaid.

A systematic running shed repair cannot, however, be delayed until defects which escape the notice of the operating staff manifest themselves. To meet this, a periodical examination is without doubt required. At what intervals these examinations shall take place and what parts they shall embrace must be decided by local and climatic conditions, the design of the locomotive and the service on which it is employed. Among matters to be considered are : boiler washing out, testing and overhaul of the boiler mountings, examination of pistons and steam distributing valves, feedwater heaters, mud extractors, as well as the intermediate inspections of the air brakes. When the result of these regular repairs on the German State Railways has been estimated as raising the output of the engines by as much as 25 %, the extraordinary rise in the average output of the German engines in service is all the more satisfactory. Naturally such an abnormal increase in output is only possible when aided by other measures which will be alluded to later.

The range of work covered by the running shed repair works must not be confined within too narrow limits. To begin with, no work calling for the use of special machines should be undertaken there and the carrying out of boiler repairs should be carefully considered. Such work belongs on account of its nature, to the main shops. This does not, however, prevent the running shed repair works from replacing stays occasionally, or from replacing complete sets of tubes. Every withdrawal of an engine from service to go to the main shops, withdraws it from service for a longer period than if the work were done in a running shed repair works, presupposing the running shed repair shop is in a position to undertake the job. The quality of the work in that shop must not be inferior to that of the main works. In order also, to ensure a high standard of work, proper supervisory

staff must be provided and it is then immaterial whether day- or contract work is in force.

It can be taken that a well equipped running shed repair shop with a sufficient labour force, which can undertake the heavier kinds of work, will obtain the highest mileage and the most economical working from its engines.

In running shed repair works where there is a large amount of night work it is necessary to employ some fitters. The heavier jobs should naturally be carried out during the day. It would appear possible to employ the enginemen on repair work. This will result in automatic reduction of the mileage made by the enginemen and also of the engine mileage, whether the engines are worked by a single set of men or are pooled.

III. — Minor examinations.

Chapter III should make clear whether the output of engines can be appreciably raised during the interval between two heavy repairs, by means of intermediate repairs, or to put it another way, whether the overall economy of the engine working can thus be beneficially influenced.

Engine maintenance would be at its simplest and cheapest if all parts were to wear at an equal rate, so that they would all fall to be repaired after the same mileage. Unfortunately the rate of wear differs. The most highly stressed parts require the most repair. This fact necessitates the intermediate overhaul which is the practice of most administrations. Some administrations however, carry out thorough repairs when, for instance tyres require re-turning. This practice undoubtedly enhances the total cost of maintenance; engines are often and for long periods unnecessarily withdrawn from traffic and parts are repaired or at best dismantled and re-erected when their condition does not require it. Pistons, valves and regulators are almost always examined during intermediate repairs. Pistons and valves are parts which have an important effect on economy and attention and lubrication are of importance if increased output is to be obtained.

It is an open question as to where the intermediate overhauls are most satisfactorily carried out. From the reports it would appear that about one half are handled in the main shops and the other half in the running shed repair works. As a general rule the main shops are usually better equipped and the work done in them is more specialized, than in the running shed repair shops. As a result intermediate overhauls carried out in the main shops should be cheapest even when the time taken to run to the main shops and return is taken into consideration, if these are well placed with reference to the running shed repair works. If, however, the running shed repair works is at a considerable distance, say 200 km. (124 miles) or over, from the main shops and if in addition it is equipped with good machine tools, it would appear that an intermediate repair could be made more quickly and in certain circumstances as cheaply as in the main shops even if tyres required re-turning. In certain circumstances tyres are not turned in the running shed repair works itself but it pays to obtain wheels, if such are not in stock, from the nearest main shops, and send in the worn sets for re-turning. In the larger running shed repair works where, owing to unfavourable road conditions, sharp flanges are frequently met with, it is economical practice to maintain a stock of spare wheels, especially if the distance to the nearest main works is considerable. Difficulties may of course be met with, results alone are the deciding factors. An investigation is nevertheless desirable, in the course of which all the existing circumstances should be gone into. Running repairs should on no account suffer for intermediate overhauls. In the case of a running shed repair shop which undertakes

intermediate overhauls, enough work must be allotted to it that an appreciable number of workers may be specialized on that class of work. On the German State Railways, during 1931, the average time occupied on an intermediate overhaul, including running to and from the main shops, was 11 days. Similar times are given by other administrations.

The question as to the value of intermediate overhauls has only be answered by the Swedish and Finnish State Railways. The former estimates the increase in output, obtained as a result of intermediate overhaul, at from 30 to 50 %, the latter at about 50 %. The German State Railway Company gives 20, 10 and 5 % for 1, 2 and 3 intermediate repairs respectively.

It is certainly extremely difficult to answer the question as put as it is apparent that the whole organisation of intermediate overhauls must be reviewed.

In the case of the administrations which resort to the intermediate repair system and, in addition, are bound by law, in the matter of their boiler inspection, to certain periods, it can happen that an engine receives an intermediate repair 6 or 9 months before its boiler inspection is due and at the date for inspection has not run the expected mileage. On the German State Railways, in such cases, the boiler inspection is only brought forward to an earlier date if the condition of the boiler justifies such a course. The Swedish and Danish State Railways deal with such a case on similar lines. The Norwegian State Railways handle the matter in a different way. They, where there is a difference between the dates for heavy repairs and boiler inspection, defer the former till the date for boiler inspection, without, however, taking the engine out of service, leaving it on light duty or in reserve. As enginemen cannot be kept continuously on light duty or in reserve, the engine must be pooled. The Finnish State Railways may only carry out the boiler examination six weeks before the legal date. In this case, the engine, if it requires repair before the legal date must be laid up until the date arrives.

No special rules exist in regard to bogies and carrying axles.

On sections where there are many sharp curves, flange wear has detrimental results on the engine mileage. With many designs of engine it is possible to change the leading wheels with the trailers. The German State Railways, the Netherlands Railways and the Madrid-Saragossa-Alicante Company frequently adopt this expedient. In the case of certain engines with 8 coupled wheels, the last named company follows this practice when the engines have run about half the estimated total mileage. Although the practice is advantageous, other lines have not generally adopted it. It is however to be recommended.

As to what extent, as a result of intermediate overhauls, engines are able to run up to the legal or planned dates for heavy repairs or examination, or if the dates laid down should be still further separated, has not been answered. As a matter of fact it is not possible to answer without investigation into the details of the problem of maintenance costs. The object of such an investigation is to determine whether it be possible, by means of a suitable system of upkeep, to raise the mileage of the locomotives between two heavy repairs, in that the engines shall actually be kept at work with the minimum of idle time during the whole period, and if it be possible to move the dates for heavy repairs even still further apart, without prejudicing the safety of operation or appreciably increasing the costs of repairs over the period, and if the mileage increases at a greater rate than the repair costs, then there will be a gain.

The question as to which engine parts most influence the mileage run and therefore require the most upkeep, was answered in various ways.

The following have been mentioned :

The firebox, chiefly in regard to the tube plate, driving gear, axleboxes, running gear, tyres, boiler tubes, driving gear, bearing metal, wheels and axles and their correct position in the frame, as well as the exact lengths of the coupling rods between the centers.

It is clear that Administrations which have to deal with bad feed water must give the closest attention to the upkeep of the boiler.

On sections with numerous sharp curves, tyres will be the governing factor, while on sections with heavy grades the axles and rods, will demand the most attention, as here the load hauled will generally be the maximum load possible.

After all, this item of the questionnaire may be translated into the following simple formula :

Can anything further be done in the way of upkeep to raise the mileage between two heavy repairs, beyond good work in the main repair shops, when making heavy repairs and examinations and careful attention during service ?

General repairs entail high costs. They must therefore be carried out at as wide intervals as safety of operation will permit. Wear of certain engine parts, however, after a certain time, endangers safety in working. What other action can be taken to safeguard the situation beyond carrying out intermediate small repairs, which will deal chiefly with these parts. On this account these small repairs — called light intermediate repairs — are economically important. The details dealt with during these intermediate repairs will be chiefly tyres, axle bearings, pistons and valves, regulators, and occasionally, where feed water is bad, tubes and stays. Such intermediate repairs will be carried out either at the main shops or in the running shed repair works or wherever the work can be done quickest or cheapest, the quality of the work being equally good. Here the position of the main shops with reference to the running repair works will be the deciding factor.

On the German State Railways several classes of engine undergo often two and even three light repairs between two heavy repairs. Even when the total costs over a given period remain the same, which is unlikely as the volume of the repairs grows in proportion to service requirements, or if they are somewhat higher, in terms of mileage, they will undoubtedly be lower per mile run, because the mileage will be very appreciably increased. The German State Railways hope that, with this system of intermediate repairs, the specified limits of time between heavy repairs will be approached, and perhaps with some classes, it may even be attained. The minor expedient of wheel changing has for this purpose, where it is necessary, still to be brought into play. Bad feed water will be difficult to combat with the intermediate repair system and will always tend to reduce mileage. It will pay to install local softening and cleaning plants to meet this trouble but the capacity of such plants should not be stinted.

IV. — Materials, design, etc.

The most important data in regard to the requirements for tyres and rails, are, so far as they have been given, set out below.

	Tyres.		Rails.	
	Tensile strength Kgr./mm² (Engl. tons per sq. inch).	Elongation. %	Tensile strength Kgr./mm² (Engl. tons per sq. inch).	Elongation. %
German State Railway Co. . .	80—92 (50.8—58.4)	...	70 (44.4)	...
Madrid-Saragossa-Alicante Co. .	70 (44.4)	14	72 (45.7)	10

	Tyres.		Rails.	
	Tensile strength Kgr./mm² (Engl. tons per sq. inch).	Elongation. %	Tensile strength Kgr./mm² (Engl. tons per sq. inch).	Elongation. %
Netherlands Railways	80—92 (50.8—58.4)	8	...	...
Swedish State Railways	72 (45.7)	16	75 (47.6)	...
Danish State Railways	75 (47.6)	12	70—80 (44.4—50.8)	12
Norwegian State Railways	80—92 (50.8—58.4)	8—10	70 (44.4)	12
Finnish State Railways	70 (44.4)	18	70 (44.4)	...
Dutch Indies Railways	80 (50.8)	13	65—75 (41.3—47.6)	12

The North of Spain Railway, the Portuguese Railway Company, and the Beira Alta Railway (Portugal) adopt specifications of the French Railways, which are not, however, given here.

The specifications of the various Administrations are basically the same; special investigations as to the material most suitable for tyres and rails are not mentioned. The tensile strength is generally so chosen, that the tensile strength of the tyre is the same as that of the rail or above it. Nothing is said in the reports as to the shape of the tyre and rail.

Replies as to the lowest permissible thickness of the tyre vary between 25 and 45 mm. (1 inch and 1 3/4 inches). Some railways differentiate between braked and unbraked wheels and allow a lower limit on the latter. On the German State Railways, engine and tender tyres, after the last turning, must still have a thickness on the tread of 36 mm. (1 7/16 inches) ; they can then be reduced in service running to a thickness of 25 mm (1 inch). This dimension also refers to braked wheels but is seldom reached. It is accepted that the minimum dimension for braked wheels should be larger than for unbraked wheels, as thinner tyres come slack easier when braked. Two points govern the fit of the tyre on the wheel centre : the correct selection of shrinkage allowance and a fine finish of the tyre and centre, so that when the tyre is shrunk on the two faces bear properly on one another. The German State Railways have proved that as many thick as thin tyres come loose, so that the possibility of the higher heating of thin tyres through braking does not seem to be apparent on the German State Railways.

On the German State Railways the flanges are brought to standard profile at each re-turning. Tyres with thin flanges are fitted on other than leading wheels, in order to improve running on curves, but never to save material, as seems to be the parctice on the Portuguese Railways (see figs. 5 to 8). The guiding of the wheels on fast running trains becomes unsatisfactory as a result of such a practice. Lubrication of flanges is practised within narrow limits by the German State Railways, the Madrid-Saragossa-Alicante Company, the North of Spain Railway (in this case for electric locomotives only) and the Norwegian State Railways.

It is not reported as to what extent wear of rail and tyres is reduced by this practice, nor can the German State Railway Company give any information on this point, as the duration of the trials is at present too short.

Hard and tough tyres will give the greatest mileage and tyres should certainly as a general rule have a higher tensile than the rails. In addition, the

tyres of driving and coupled wheels on the same engine should have the same tensile in order that no one of them should wear more than the others and so call for the premature turning of the whole set. The question as to know whether a more favourable rail profile may be found is likely to be the subject of important trials to be undertaken by the German State Railway Company. The running surface must be wide enough not to permit the specific pressure between wheel and rail to become excessive. The rounding of the rail head angles conditions the wear of the flange. Experience shows that under the passage of the wheel, rounding of the head of the rail takes place, the radius of which is

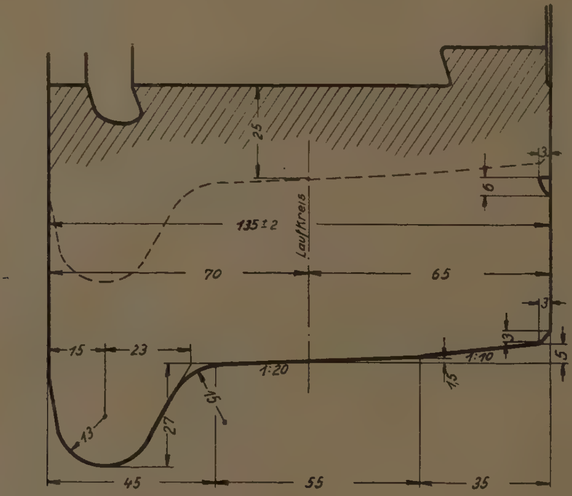


Fig. 1.

about 250 mm. (1 inch). Perhaps it may be possible, without danger, to increase the contact area of the flange in order to reduce the wear still further. At the moment nothing can be said on this subject as the test results are not available. In order to reduce the flange wear on sections with sharp curves, the German State Railway Company has fitted the leading wheels of its locomotives with tyre watering arrangements. Results are poor ; automatic lubrication of the flanges when on curves would be preferable, if designed to deliver the lubricant properly to the radius of the flange without greasing the running surface. The existing devices are not yet satisfactory. Tests have been made in the way of greasing the rails themselves on sharp curves. Here also there is the danger that the grease may work on to the running surfaces and cause the engine to slip.

The permissible thickness of the tyres will not influence the mileage run by an engine between two heavy repairs, as the tyres can be turned sufficiently often during their life. It is different if the

tyres often become loose. That should be prevented by careful work.

The German State Railway Company uses a stuffing box as shown in figure 2. The gland and packing rings are made from soft cast iron; they are replaced after about 200 000 km. (124 000 miles) but do not require any upkeep.

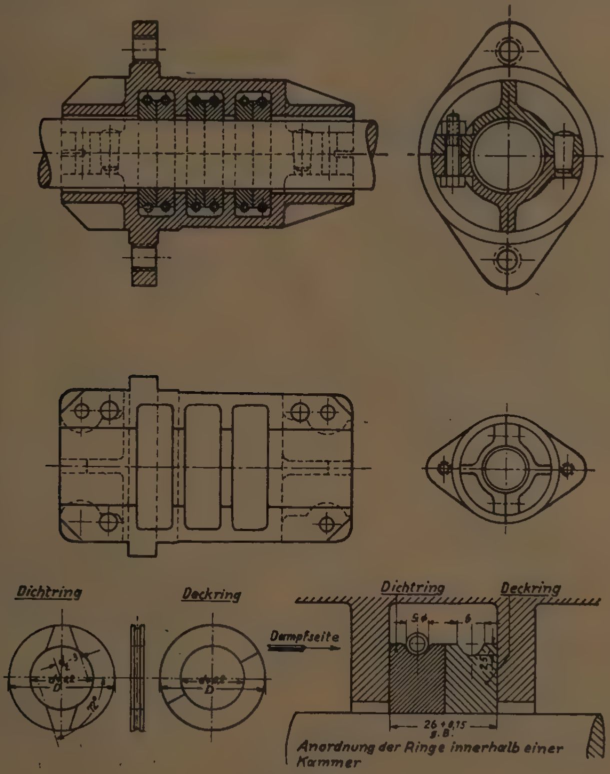


Fig. 2.

Explanation of German terms:
Dichtring = Tightening ring. — Deckring = Coverring. — Dampfseite = Steam side. — Anordnung der Ringe.... = Ring arrangement inside chamber.

This stuffing box works reliably and economically.

The Portuguese Railway Company, Lisbon, the Beira Alta Company, the Dutch East Indies Railways and the Norwegian State Railways also use stuffing boxes with cast iron packing rings which follow the German State Railway Company's pattern.

The remaining railways use stuffing

boxes with soft metal packing. The reply does not state if this is true of the Netherlands Railways. The stuffing boxes in use on the Danish State Railways are not described.

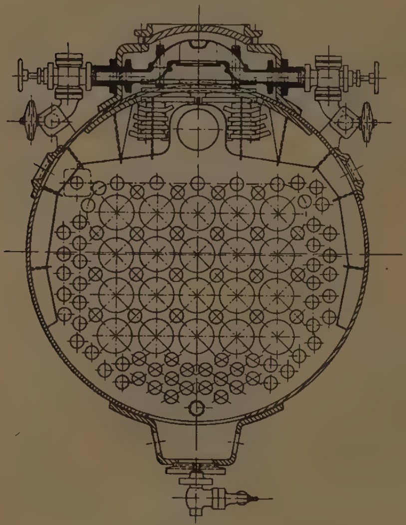


Fig. 3.

The abstract, page 997 shows the mixtures in use for bearing metal, so far as they have been given.

As shown, there are only small differences. White metal mixtures are not at present fully satisfactory as wear is still too great in service.

All Administrations agree that when the feed water is bad, the mileage of engines is seriously affected in spite of the greatest care. Of the measures taken to improve matters the following may be mentioned.

a) Treating the cold water supply ;

b) Use of anti-scale compositions added to the water in the tender ;

c) Apparatus (mud separators) which remove scale-forming matter on its entrance to the boiler and make its removal easy and certain.

Treating the cold water by the lime-soda or similar method, is expensive, if the plant is so generously designed that the scale forming matter has time to settle in the filters. The anti-scale compositions have the disadvantage that their reaction varies with the chemical analysis of the water, an unfavourable condition, engines not always taking water at the same stations.

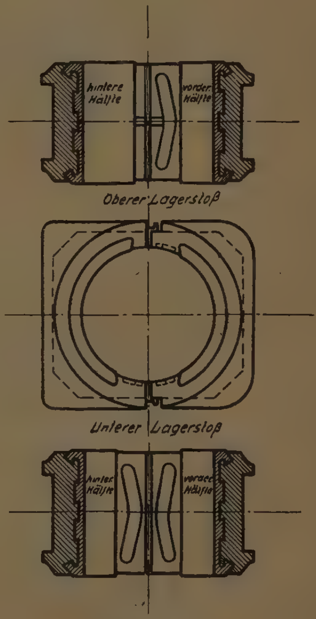


Fig. 4. — Arrangement of felt strip in rear driving rod bearing.

Note :
Hintere (vorder) Hälfte = Rear (front) half. — Oberer (unterer) Lagerstoss = Upper (lower) bearing joint.

	Brass.	White metal.
German State Railway Company.	Copper 85 % Tin 9 % Zinc 6 %	Tin 80 % Antimony 12 % Copper 6 % Lead 2 %
Madrid-Saragossa-Alicante Railway	Copper 81.5 % Antimony 14.5 % Yellow metal 4.0 %	Tin 84 2/3 % Antimony 9 1/3 % Yelow metal 6 %
	(Yellow metal is composed of 65 % copper and 35 % zinc; it contains 8.5 % phosphor).	
North of Spain Railway Company.	...	Tin 85 % Copper 5 % Antimony 10 %
Portuguese Railway Company	Passenger locomotives.	Copper 5.55 % Antimony 11.12 % Tin 83.33 %
	Goods locomotives.	Copper 3.0 % Antimony 14.5 % Tin 40.0 % Lead 42.5 %
Beira Alta Railway	Copper 85 % Tin 9 % Zinc 6 %	Tin 80 % Antimony 12 % Copper 6 % Lead 2 %
Netherlands Railways	Copper 85 % Tin 14 % Zinc 1 %	Copper 6 % Tin 84 % Antimony 10 %
Dutch East Indies Railways.	...	Tin 75 % Antimony 15 % Copper 7 % Lead 3 %
Swedish State Railways	...	Tin 80 % Antimony 13 % Copper 7 %
Danish State Railways	Copper 80 % Lead 10 % Tin 10 % Antimony —	Copper 5.5 % or 10 % Lead 3.0 % — Tin 80.0 % Antimony 11.5 % or 10 %
Norwegian State Railways	Copper 84 % Tin 15 % Zinc 1 %	Tin 82 % Copper 9 % Antimony 9 %
Finnish State Railways	...	Tin 85 % Antimony 10 % Copper 5 %

Mud separators are fitted to large numbers of the German State Railway Company's engines and have proved very suitable and efficient.

Fig. 5. — Profile No. 1.

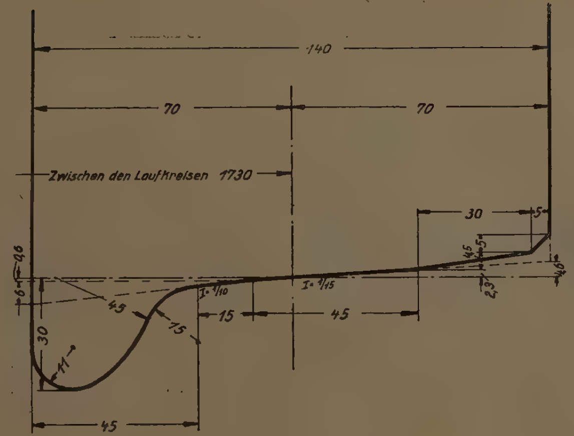


Fig. 6. — Profile No. 3.

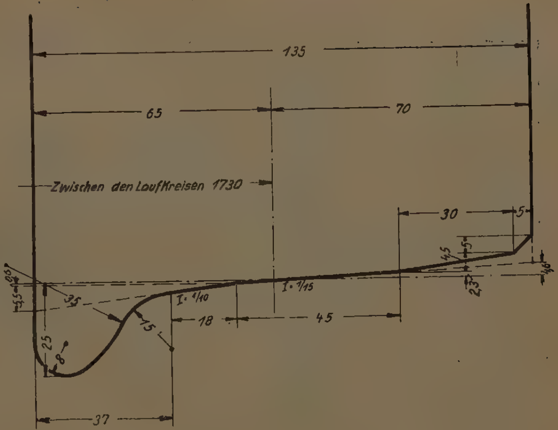


Fig. 7. — Profile No. 5.

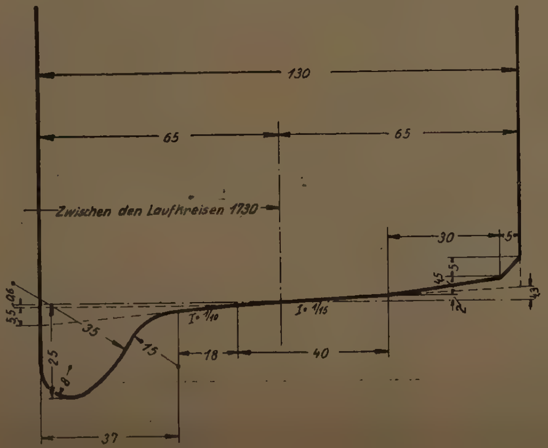
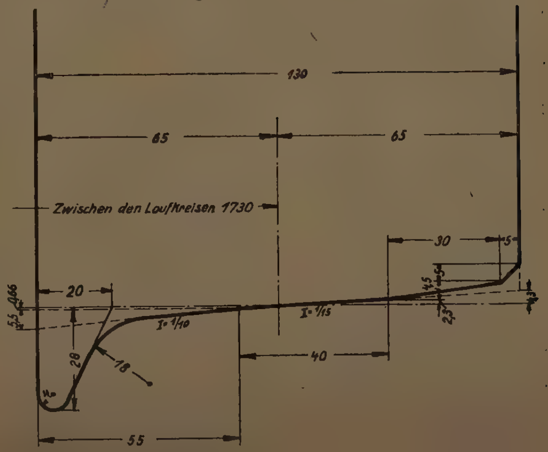


Fig. 8. — Profile No. 7.



Figs. 5 to 8. — Tyre profiles, Portuguese Railway Company.

Foreign lines have not reported the use of mud separators; anti-scale compositions are only seldom used; occasionally water is purified from scale forming matter in the cold state.

Compared with the methods mentioned, frequent and thorough washing out is the simplest method of reducing to a minimum the damage from bad feed water.

Little need be said on the subject of the extreme importance of a supply of good feed water. If good water can be obained in the neighbourhood, the cost of bringing it from a considerable distance should not be objected to. Fixed softening plants and scale preventing compositions are only partial palliatives. If bad feed water has to be used, frequent boiler repairs will raise maintenance costs considerably and reduce the output of the engines. Fixed plants for softening water should be installed on such a scale that the salts in the filter and in the purifying installation will be sure to settle. The operation of the plant should be controlled by daily analyses.

When hard water is used valve- and piston rings, valve liners and cylinders wear to a greater extent. Softened water is inclined to prime and can cause water blows which may result in heavy damage. It has been frequently observed that a given water primes and gives trouble when water from a particular station is mixed with it. The drivers are aware of these stations and avoid them if possible. If the water at the home station is unsuitable it is often possible to take water of good quality during the run.

On saturated steam locomotives, the valves and pistons are lubricated by displacement lubricators which deliver the oil in the form of spray. This evaporative lubrication when tried on superheated engines, did not work well. Nowadays cylinders and valve liners are lubricated by means of pumps which deliver the oil to these points in fluid form; on the German State Railways the piston receives approximately twice the quantity fed to the valves.

The German State Railway Company places a high value on the uniform lubrication of the pistons and valves. The cylinders and valve chests are therefore fitted with check valves which only open when a predetermined pressure is reached in the oil pipes. Cylinders and valves working with superheated steam should begin to receive oil after a few revolutions of the wheels, and the oil leads should, therefore, not empty themselves while running light or standing. The oil check valves serve to prevent the variations in steam pressure, which take place in the cylinders and valve chests, from detrimentally affecting the oil supply, as commonly occurs with displacement lubricators.

Axle boxes are almost universally lubricated by means of syphon wicks. Only a few Administrations, among them the German State Railways have equipped a small proportion of their engine stock with oil pumps. No advantage has been obtained from this system.

Rod bearings have either worsted needle or pin oiling.

Superheater and mineral oils are almost everywhere supplied in accordance with similar specifications, which are in the main the same as those of the German State Railway Company. The composition of white metal and bearing metal is extremely important. They must possess sufficient strength and toughness to withstand heavy shocks and high specific pressures. Since white metal inserts cannot at present be dispensed with, care must be taken to ensure the intimate union of the white metal with the bronze bearing.

For a long time the present form of both white metal and bearing has remained unchanged, and it can be concluded that, at date, appreciably better alloys are not available, although results in service are not altogether satisfactory. If the wear of the white metal is

to be kept as low as possible, good and sufficient lubrication must be provided, especially if the specific pressures between journal and bearing, as in the case of connecting and coupling rod pins, are very high. Driving crank pin bearings, especially in the case of large two-cylinder engines are very highly stressed. On the engines of the German State Railway Company, oil is led to the axlebox bearings at two points and is distributed over the whole bearing area by means of special oil grooves. Where axle journals are long, as in the case of carrying or bogie axles, there should be no hesitation in providing auxiliary lubrication for the radius of the journal. On the newer engines of the German State Railways, the bearings of the carrying axles, which are 300 mm. (11 13/16 inch) long have been fitted with auxiliary oil boxes which deliver oil direct to the radii.

The German State Railway Company has just fitted the brass faces of the connecting- and coupling rod bearings of some of their engines experimentally with felt strips so designed as to return the oil to the centre or bearing surface of the brass (fig. 4). These trials have so far been extraordinarily successful, in spite of the fact that conclusions as to the width, the shape and the method of fixing the felt strips, have not yet been definitely arrived at. Oil consumption and bearing wear have been considerably reduced and the life of the bearings has been increased. Satisfactory lubrication of all working parts is of the greatest importance to the mileage output of the engine. The more carefully it is carried out, the fewer working days will be lost. Often pistons and valves are over-oiled and the resulting carbonisation of the asphalt in the oil by the highly superheated steam may cause rapid wear. It is obvious that all Administrations endeavour to use such quality of oil and grease as the strenuous character of locomotive operation demands.

Stuffing boxes do not have any great influence on the engine output, as complete failure, of even the soft metal packing, is not to be feared. On the other hand, when unsuitable stuffing boxes are used, the piston- and valve rods wear much more quickly and require more frequent repair.

V. — Operation.

The high capital cost and the resulting interest charges must of necessity lead to a thorough utilization. The continual progress in design encourages the tendency to scrap the locomotive at a not too distant date. The majority of Administrations therefore have introduced multiple crewing. The Portuguese Railway Company, and the Dutch East Indies Railways, alone, still retain the single set of men system. The latter company provide a second fireman on the bigger engines.

The Norwegian State Railways report that they man their smaller shunting engines with one man. Whether, in addition, they work with single or multiple sets of men is not stated.

Single manning gets little use from the engine; it is convenient in that the staff duty sheet has not to depend on the locomotive. Conditions for repair and attention to the engine are undoubtedly the most favourable under this system.

With double manning, the utilization of the engine is then considerably better. If the men go off duty at the station, staff is required to prepare and stable the engine. Useful service is increased. Attention to and upkeep of the engine, are in this case also good, so long as the engine is handled by two particular sets of men.

The three sets of men system is common in shunting service and is generally practised by the German State Railway

Company on express and goods service, in isolated cases. In this case the maximum mileage can be obtained from the engine and though the cost for personnel is somewhat increased, the total costs are lowest. Care and repair of the engine suffers, because the engine only returns to its home shed every 3 to 5 days and for the rest of its time stables at out stations. The engine staff must therefore show an increased interest and, in addition, the running arrangements must be such as to permit of proper rest intervals on wash-out days. The three sets of men system can only be worked when specially favourable conditions exist. It has been found unnecessary to provide a second fireman on even the heaviest German engines.

The maximum mileage obtained on the various railways during one uninterrupted turn of service varies very greatly. Under the single set of men system the rules, as to hours of work of the crew, might easily operate disastrously. With double manning the locomotive output should no longer suffer from the personal factor. Coal, the size of the grate and the capacity of the ash pan do not for the most part affect matters, but on heavy trains and long through runs coal with a large percentage of clinker should be avoided; a large grate which calls for a low firing rate is of considerable advantage in all cases. Mechanical stoking has only been installed on the small number of pulverized fuel engines on the German State Railways.

Loading of grates and heating surfaces vary very much and are generally given only for maximum outputs.

As a rule the engines of the German State Railway Company evaporate, per hour, 35-40 kgr. of water per square metre of heating surface (7.2 to 8.2 lb. per sq. foot) (not including superheater) and, in the same period, burn from 270 to 370 kgr. of coal per square metre of grate area (55.3 to 75.7 lb. per sq. foot). At maximum output these figures are increased to 60 kgr. (12.3 lb.) of water and 400 kgr. (82 lb.) of coal. Similar results are obtained on other lines.

The highest efficiency is obtained from the boiler with a heating surface loading of about 35 to 45 kgr. (7.2 to 9.2 lb.) of steam per hour. If the engine is worked at a higher rate for lengthy periods, the amount of repairs and the consumption of coal will increase out of all proportion and the output between two heavy repairs will fall sharply; in short economy will decrease. An engine will give its best output if it is operated neither above nor below its best boiler efficiency.

The average and maximum outputs of the engines of the German State Railway Company, between two heavy repairs are given under question 10 (see appendix). The gratifying results may be traced partly to the intermediate repairs. The German State Railways believe that by that means they can keep their total maintenance costs at the lowest level.

The question as to what time interval is required between two journeys has been answered by the Dutch East Indies, the Finnish and the Swedish State Railways. The first gives from 2 to 3 hours and the Finnish State Railways from 30 to 40 minutes; no figures are given in the report of the Swedish State Railways. All other Administrations have given the time required to turn an engine on the turntable. What was required was the time within which enginemen arriving at a terminal- or turning station could take over another train running in the opposite direction.

This time must naturally vary considerably; it depends on the type of engine, the mileage that it has already run, on the station lay-out and on the amount of traffic. If it is a case of a tank engine in suburban or local service, which does not have to be turned, does not require coaling, and only needs its tanks to be filled, 10 to 15 minutes are enough. If it must be coaled, then 25

minutes will be required. When a heavy express, passenger, or goods locomotive with separate tender, which has just completed a trip of from 150 to 300 km. (93 to 186 miles) has to be turned for its return trip and must be coaled and prepared and have its fire cleaned, from 2 to 3 hours must be allowed.

The main line engines of the German State Railway Company are equipped with drop grates and ash pan bottom doors in order to deal with ashes quickly. Lines which operate with shaking grates mostly use them while running, to shake up the fires. If engines are to make big mileage, they must make as long runs as possible without change. Train mileage must therefore be apportioned to the various sheds and suitable duty sheets made.

It is preferable to work long sections from a running repair depot situated in the center thereof. Take as an example a length A—B—C. The repair works are situated at B and the engines and men have their home station there. The engines turn round at A and C and the men change at B while the engine runs through. The frequency of this change depends on the length, the train load and the time taken to turn round at A and C. If train conditions necessitate a long delay to the engine at A and C, then it will be preferable to operate the trains from the ends of the section viz. A and C.

In order to increase the mileage between general repairs, the German State Railway Company has introduced premiums. A basis mileage output has been fixed for each individual class of engine at each running repair shop. If this mileage is exceeded, the personnel receives a premium which increases progressively with the mileage. This may be as much as 1 000 Reichsmark for two sets of men. These premiums were introduced in 1927. The average mileage at that date, viz. 73 000 km. (45 360 miles) has been raised to 113 000 km. (70 220 miles), i. e. by about 55 %. The engine driver and fireman each receive one half of the amount due for the mileage made by them. All Administrations consider proper cleanliness as necessary for safe and economical operation. The psychological effect of a clean engine cannot be too highly valued. The extra cost of well cleaned engines if it is not excessive, will be more than wiped out by the increase in output.

The German State Railway Company also pays coal premiums which must naturally tend to increase the attention of the engine staff to the cylinders, valves, fireboxes and smokeboxes and this must also result in a good and economical state of repair.

In short, the following methods of operation will result in high mileage output. First, the multiple staffing of engines, whether single, double or treble. The staffing must however be according to a proper plan, as sets of men selected haphazardly will have unsatisfactory results. The lengths of the runs should be as long as the particular railway system will permit. It is preferable to work the engines from the centre of the section, because the men can be changed and the engine itself can travel over the section two or three times, before it is taken in to its home repair station. The turning time at the turning stations plays an important part. When drawing up locomotive working tables, care must be taken that the time allowed for turning round is not too short. In the first place, where the work is heavy, thorough fire cleaning is necessary, and in addition time must be allowed for minor adjustments. Lengthy stops are also undesirable. The most suitable running arrangement must therefore be worked out in accordance with the timetable. The engine personnel must have an interest in high engine mileage. The rules as to working hours limit the individual output of the personel within a given time ; the engine mileage- and coal premiums, given by the German State

Railway Company, increase the intensity of the effort during the working time, while the allowances paid for each hour the engine is running give an additional increase. The value of clean engines is also to be appreciated in the same way. The locomotive staff should take a pride in their engines.

And now with regard to the engine itself, its size and its work.

The question in regard to the proper loading of the boiler has unfortunately only been answered by the German State Railway Company and the Finnish State Railways. As hourly evaporations of 35 to 40, and 32 kgr. per m² (7.16 to 8.2 lb. and 6.55 lb. per sq. foot) respectively are given with a coal combustion of 300 kgr. (61.4 lb. per sq. foot) of grate area, the normal demand falls short of the maximum boiler-capacity, by about the usual figure. As the ratio of grate area to heating surface is a fixed one, the lower loading of the heating surface is to the benefit of the grate. Where engines have to run high mileage, the grate should not be too highly stressed and in this connection the quality of the coal is important. Maintenance of a thin fire, where the coal is good, prevents troublesome formation of clinker and helps the engine in the direction of high mileage output.

The design of the boiler has a good deal to do with obtaining high mileage. On the other hand the numerous tubes, rivets and stays are a fruitful source of trouble when a boiler is highly loaded over long periods. It is therefore very desirable that the boiler portion of an engine should only be worked to from 60 to 70 % of its capacity, and that the engine itself should be correspondingly powerfully built.

The quality of the coal used should never be a factor in limiting the mileage output, at least in so far as length of trip is concerned, on any of the European Railways.

VI. — General.

The repair cost per engine-mile will be lowest when the engine mileage between two heavy repairs is highest, without the total cost of the heavy repair or examination being also considerably increased. So long also as the mileage increases more rapidly than the repair cost, the engine economy will have been properly controlled. Operating under otherwise equal conditions, an engine which works with a medium loading of grate and heating surface, will remain capable of service for a longer period and will run more miles than one which is, for long periods or continually, loaded to 100 % of its tractive capacity. The tendency to employ powerful engines is therefore economically justified. Besides, the engine then works under the best thermal efficiency and consumes the smallest amount of coal per horse power.

An improvement in design in the shape of a three-piece driving axlebox bearing, has been introduced by the German State Railways and by the Netherlands Railways.

An improved arrangement of the tube plates and the use of longer stay bolts has permitted the Madrid-Saragossa-Alicante Railway Company to reduce repairs to its fireboxes and to increase the mileage.

In order to reduce the work of the boiler, the Beira Alta Railway has introduced exhaust steam feed water heaters experimentally. It can be accepted that a large number of Administrations use exhaust steam feed water heaters.

In order to protect their boilers, the German State Railways have generally installed mud separators which have been mentioned elsewhere.

The locomotive output premiums have brought the German State Railways by far the greatest results. They have resulted in the raising of the average out-

put of their engines, in a very few years, by more than 55 % and in the case of not a few main line engines the increase in output is from 200 to 300 %. The Swedish and the Norwegian State Railways report a novelty. When white-metal is being cast into rod brasses they are rapidly revolved in order that centrifugal action may ensure a compact casting.

All railways only deal with the axle journals in the main repair shops, when examinations and general repairs are carried out. Double crank axles are periodically examined on the German State Railways when defects have been observed or are expected to exist, which render examination necessary. The Danish State Railways examine such axles, generally after 75 000 km. (46 600 miles) and single crank axles after 100 000 km. (62 100 miles).

The importance of axle and rod bearings in connection with mileage run is recognised by all administrations. The care taken by the German State Railway Company in the manufacture and handling of these items, can be seen from the report. Changing the bushes of the rod bearings is carried out by the works. The careful way straight and crank axles are handled is to ensure absolute safety : it may be doubted if it is still necessary at the present time. When the piston thrust is properly taken by the axleboxes, as in the Obergethmann bearing, there will certainly result a reduction of wear and improved maintenance. The question of bearing lubrication cannot be too carefully attended to. If even in the presence of high pressure, an even oil film is present between the bearing faces, the alloys, such as they are at the present day, will give satisfaction. The cause of hot bearings is not so much the quantity of oil fed to them as the manner in which it is led to them, and the unsatisfactory distribution of it.

VII. — Concluding observations.

1. *Maintenance of the locomotives.* — The system and the carrying out of the work of maintenance of the locomotives between two general repairs is of the utmost importance and must have for its aim, the maintaining of the engines in the best possible condition. The cost of upkeep will be compensated for by the thorough utilization of the engine with a minimum of repairs ; in other words, the capital expenditure for running engines can be kept correspondingly small. As the cost of general repairs is very heavy, the reason for undertaking them must be the *general* state of wear of the engine. As to whether it is necessary to fixe dates legally for the examination of the running gear need not be discussed. *Periodical* examinations of boilers, demanded by law are at least desirable in the interests of safety and maintenance. Distinction between internal and external examination of the boiler may be dispensed with. In the case of hard worked engines, safety and economy will be best assured if, in accordance with the Danish plan, a 4-yearly internal examination of the boiler is provided for, with which a suitable general repair and examination of the running gear of the engine and tender is coupled, during which the frames are gauged and all parts brought back to original dimensions, or according to work limits (*). If, as in the case of express engines, for example, the stressing of the engine does not permit of fixing the heavy repair periods at 4 years, the work done at earlier general repair periods can be restricted and principally confined to the running gear and details and the repair of boiler defects which

(*) Original dimensions are those given on the drawings. The work limits vary, according to fixed allowances, from the original dimensions.

have been detected. In the case of a few of the engines, a 4-yearly internal boiler examination is probably unnecessary and too costly. It is therefore to be recommended that the internal examinations should take place at the latest, after 6 years, while, in case of need, they could be put forward. If engines are carefully maintained, the external boiler examination is rendered unnecessary, and the necessity for it is not clear. In the case of new engines, the first internal examination may be deferred till the eighth year.

Excessive wear of particular parts should be made good by intermediate repairs. For the rest, all work during running repairs, general repairs as well as intermediate repairs, must be carried out with the greatest care and accuracy.

During intermediate repairs certain parts of the engine must be periodically examined. While it is certain that such regular attention will appreciably increase the output between two general repairs, how much it will do so, can naturally only be estimated.

There will be controversy in regard to intermediate repairs; it is our opinion that they are indispensable for economical locomotive operation. It is not however economical to entrust regular repairs to the engine crews. If this is done their output and that of the engines will be reduced.

2. — *Design and material.* The rough handling and the heavy demands made on the locomotive call for the robust construction of all its parts, careful work and the use of the best materials. The quality of the various materials must be laid down in special specifications. The tyres, axlebox and rod bearings, the lubrication of moving parts, the stuffing boxes and boiler are among the most important parts.

Hard and tough tyres will give the best results as regards mileage. The permissable thickness to which tyres may be worn down does not affect the mileage, because tyres of the thickness usually fitted, can be turned many times and therefore suffice for the mileage between two general repairs.

The results of researches carried out by the German State Railway Company do not justify any discrimination between braked and unbraked tyres, in view of the fact, that just as many thick tyres come slack as thin ones.

The introduction of superheating gave rise to considerable difficulties in regard to piston and valve rod tightness. The soft packings did not offer enough resistance to high temperatures, nor were the soft metal packings satisfactory. These troubles have been eliminated by the cast iron stuffing box (fig. 2). The cast iron gland and packing rings remain tight even when the crossheads are badly worn.

Axlebox and rod bearings have the greatest influence on the mileage run. The high pressure per square inch of area and the heavy shocks affect the bearings adversely. The bronze shell with white metal insets predominates on the German State Railways and on the lines of the other administrations to whom questionnaires were addressed. Intimate connection between the bronze and the white metal is of the utmost importance. There is hardly any alteration required in the composition of the alloys themselves.

The Obergethmann bearing may be noted as an improvement, which has been employed for driving axles and it would also be of value on coupled axles for absorbing the large horizontal stresses and thus protecting the axlebox and rod bearings. When fitting up all rod brasses, liners are applied, which can be changed for thinner ones as the brasses wear.

A description of the methods of handling the axlebox and rod brasses, in the shops of the German State Railway Company, with a view to improving their

mileage, is given in section VI of the appendix.

An appreciable improvement in the mileage run by axle and rod brasses between two renewals has taken place. The mileage run by the passenger and express locomotives of the German State Railways has reached 60 000 to 120 000 km. (37 300 to 74 600 miles) while the mileage of goods engines brasses is about 40 000 km. (24 850 miles).

A superheat oil is used on the engines of the German State Railways for oiling the pistons and valves of superheated engines ; this oil has a flash point of about 300° C. (572° F.). This oil is satisfactory with steam temperatures of 400° C. (752° F.) and over. The old theory that the flash point of cylinder oil should lie at least as high as the temperature of the steam, need no longer be maintained. On the other hand superheated steam necessitates a different distribution of the oil to valve chests and cylinders and the oil should be supplied in fluid form.

The high specific pressure in the axle-box and rod brasses, calls for the very careful distribution of the oil over the whole bearing surface and to the radius. Long journals may call for an additional lubrication of the latter.

The question of feed water heating plays a very important part in steam locomotive design. A supply of good feed water cannot be valued too highly. The distance that water has to be brought, even if the distance is many miles, is of secondary importance ; a comparison of the figures for interest and amortization on the cost of the pipe lines, and the expense of upkeep and increased consumption of the engine, will undoubtedly favour the provision of good water, even through long pipe lines. The limit in this matter is fixed by local conditions and the quality of the water supply.

If fixed softening plants are to be installed, they must be of generous dimensions. The last and worst palliatives consist of the so called scale removers ; when these are used the precipitated scale remains in the boiler. If such palliatives are employed frequent washing out of the boiler will always be absolutely necessary.

The design of the boiler must be such as to permit of proper washing out. The openings must be so placed that every part of the interior of the boiler may be reached by the water jets, and the scale thus removed.

The mud separator, which is placed in a special dome, is a satisfactory means of depositing the scale in a part of the boiler where it can cause the least damage.

3. *Operation.* — The engines of the German State Railways are today loaded to about an average of from 60 to 75 % of their maximum capacity. This fact has an important influence on the mileage output because, beyond this point, the repair costs and the number of days under repair no longer rise in proportion to the increase in the mileage, but increase at an appreciably faster rate.

Undoubtedly the provision of heavier engines leads to an increase of capital invested per locomotive, but the increased output permits of the use of a smaller stock of engines, and besides less accommodation and handling plant are necessary.

Let it be said also that the horse-power-hour, when the locomotive is favourably loaded is less expensive as regards fuel, to say nothing of the increased flexibility of operation.

With the high costs entailed by locomotive operation, unproductive labour must be kept as low as possible, while productive labour must be raised as much as possible. This can only be achieved by the use of double or multiple sets of men on main line engines, in combination with long runs without changing engines.

Turning round times and the time occupied in cleaning fires are of influence on the full utilization of locomotives. The arrangement of the locomotive yards must be properly thought out on that account, and the approach lines must be arranged to admit of the rapid access of the engines to the sheds, as this makes for saving in staff and engine time.

The introduction of mileage- and coal premiums, as well as running time allowances on the German State Railways, has shown that the money incentive tends to encourage the staff in the direction of the maximum output, so that it may be said that the professional fitness of the staff is of the utmost importance.

4. *General.* — No basic alterations have been made in the locomotive during the last ten years. Nevertheless, during this time improvements have been made, on the German State Railways, which have influenced the output. Among these may be mentioned the Obergethmann bearing, the increase in the dimensions of the highly stressed connecting- and coupling rod bearings and the improvements in the design of the pressure equalizing valves, with the object of reducing compression and, above all, of destroying the vacuum in the cylinders and valve chests when the engine is running without steam. This has reduced the fouling of the valves and pistons and increased the intervals between the examinations of these parts. Drop grates and ash pan bottom doors must also be referred to. In addition, trials are in progress with plain and corrugated iron fireboxes, welding in of small and large tubes and the use of repaired firebox plates and stay bolts, as well as the adoption of higher boiler pressures, and the pulverized fuel locomotive.

The recent reorganization of the repair shops of the German State Railways also had a marked influence on locomotive mileage. Modern machine tools and methods of work, good gauges and a large provision of spare parts have made it possible to reduce by about 50 % the time taken for repairs. At the same time the work is now better and more accurate.

The improved equipment of the running shed repair shops and the extra care taken of the engines in them, which among other things ensures a high grade of cleanliness, must also be mentioned.

Machine tools and gauges have been provided for dealing with the driving- and coupled axles and the driving- and coupled crank pins, and with the aid of these tools, the smallest errors can be discovered and made good.

APPENDIX

Summary of replies to the questionnaire.

German State Railways.

I. *General repairs.*

1. The general repairs of locomotives depend on their condition. Safety of operation and economy fix the period of time, provided the examinations prescribed by law and mentioned under (3) do not necessitate an earlier repair.

2. Certain laws exist which provide for the examination of locomotive boilers, frames, tenders, and the brake.

3. These examinations take place after a certain period of time. They are not affected by the mileage output.

The following must be carried out :

a) The examination of the frames and

of the tender at each general repair, or at least every three years.

b) The internal examination of the boiler, at the latest 8 years after it was put into service. This examination must be repeated at the latest after 6 years.

c) The external examination of the boilers by pressure test after at most 4 years, between the internal examinations.

If the internal examination has been repeated within 4 years at most, the external examination c) due after the last internal examination, drops out. The periods for frames, boiler and tender stand by themselves. They commence, with the date of entry into service after the delivery of the engine or an examination. Trial or handing over trips do not count as entry into service. Until the end of two years, the periods can be extended :

— by the time occupied in general repairs

— by the time an engine is laid off, if this is longer than 2 months.

Boilers, if they have been continuously more than two years out of service without interruption, or have not been used longer that two years, since the last pressure test, can only be taken into service after a pressure test.

d) The main examination of the engine and tender brakes is carried out at each general repair or examination of the locomotive. An intermediate brake examination must be carried out every six months. All examinations can be carried out before their due date. That occurs when general repair is necessary and the next examination falls due in such a short time that the engine run cannot be out.

The date of each examination must be marked on the boiler or frame.

4. The examination periods are the same for all engines. The general repairs will differ in accordance with the engine classes as they are dependent on the mileages run. As a average, repairs are due to :

Express engines, after 18 months and 175 000 km. (108 740 miles).

Passenger engines, after 18 months and 150 000 km. (93 210 miles).

Goods engines, after 24 months and 100 000 km. (62 100 miles).

Shunting engines, after 36 months and 75 000 km. (46 600 miles).

5. The internal and external examinations carried out under 3 b) and c) are different. At the internal examination certain work, specified under (6) must be carried out. For the external examination, all lagging must be removed from the boiler so that every part can be examined externally. At the internal examination, all internal details not acting as stays must be removed. The boiler must be examined for corrosion, cracks and other defects. In both instances a water pressure test must be carried out. The test pressure must exceed the maximum permissible steam pressure by 5 kgr./cm² (71.1 lb. per sq. inch.)

Boilers which show permanent set at this test or which at the maximum pressure pass water through the joints in a form other than fine drops, may not be put into service again in that condition.

6. Heaters, feed arrangements, superheater tubes and regulators must be removed for the external examination. Defective tubes, smoke tubes and stays must be removed and the boiler freed from scale as far as possible.

The same work is carried out for the internal examination ; in addition the superheater header and the internal steam pipe are taken out and tested with a water pressure which exceeds the working pressure by 5 kgr./cm² (71.1 lb. per sq. inch). All tubes and smoke tubes are removed and the boiler shell, the firebox, smoke box, rivets, stays and other anchorages are carefully tested and if necessary, repaired or renewed. The

internal and external examinations are always carried out at the same time as the examinations of the frames and the brake. The frame is gauged, tyres are re-turned and the axle bearings and rod bearings are renewed at the same time.

When the internal examination is carried out, all parts of the engine are restored to their original dimensions.

Other countries.

Madrid, Saragossa and Alicante Railway Company.

I. *General repairs.*

1. The general repairs depend chiefly on the condition of the boiler and the driving gear.

2. No legal requirements exist regarding the frames, the brake, etc. : In the interests of safety it has been arranged that the boiler should be hydraulically tested after repair, if it has previously run 100 000 km. (62 100 miles).

3. General repairs are taken as replacing examinations; the are usually carried out after a predetermined mileage which is raised or lowered according to the condition of the engine.

4. The time and mileage covered between two repairs varies according to the class of the engine.

5. The internal examination of the boiler is carried out during the general repair when the tubes are changed. This occurs after an approximate mileage of 120 000 km. (74 570 miles), or should serious corrosion be anticipated. The firebox tube plate is usually renewed after double — and the whole firebox after three times the above mileage. If the tubes are not changed the boiler will only be examined internally in so far as is possible. The work terminates with an hydraulic test. No distinction is made between internal and external boiler examinations.

6. In this case the following work is done to the boiler : repairs to tube plates if they are not renewed, changing stay bolts and crown stays, overhauling the firebox side plates, etc.

North of Spain Railway Company.

I. *General repairs.*

1. General repairs are made dependent on the condition of the boiler, the firebox, the driving gear and especially the frames.

2. It is laid down by law that the boiler must be put through an hydraulic test after each repair. There are no legal requirements in regard to the frame or brake, etc.

3. The general repairs, which here replace the examinations, are usually carried out after a fixed mileage.

4. This mileage varies according to the class of engine.

5. After the tubes have been removed, the boiler is examined and repaired and is then subjected to a pressure test. No distinction is made between internal and external examinations of the boiler.

6. All necessary work is done when the boiler is examined, as for instance changing of tubes and stay bolts, and fitting of patches in the firebox or boiler shell.

Portuguese Railway Company.

I. *General repairs.*

1. General repairs depend on the wear of the tyres. This is found desirable in the interests of economy and safety, because the wear of the tyres and the condition of the engine are closely connected.

2. No legal requirements exist for the treatment of the boiler, the frames, or the brake.

3. Examination is undertaken after a certain mileage output.

4. This mileage varies with the class of engine.

5. Tubes and smoke tubes are removed. The boiler is examined throughout; all damaged or worn out parts are repaired or renewed. Wether an hydraulic test is made, and the pressure applied or not is not to be gathered from the report. No distinction is made between internal and external examinations.

6. At each examination, a large number of stays and all the tubes are changed; the amount of work done depends on the condition of the boiler. All work necessary for the safety of the boiler is done.

Beira-Alta Railway Company.

I. *Repair including lifting the engine.*

1. General repairs, which are shown in the report as « repairs including lifting the engine » depends on the condition of the boiler tubes. Manifestly this refers to engines working with bad feed water, in which case the mileage between two repairs is limited by the boiler tubes.

2. No legal requirements as to the examination and treatment of boilers, frames or the brake, exist.

3. Examinations are made after a fixed mileage output.

4. This output differs in accordance with the class and service of the engine.

5. When examining the boiler, the tubes are removed and the boiler is cleaned and examined both internally and externally. The reply does not state whether an hydraulic test is applied or not.

6. The tubes are replaced and the boiler and firebox repaired, so far as is necessary. The safety valves are also put in order.

Netherlands Railways.

I. *General repairs.*

1. The general repair depends on the condition of the engine.

2. Legal regulations exist regarding the treatment and examination of the boiler; there are none regarding the frames and brake.

3. Examinations of the boiler are made after a fixed period.

4. The period is the same for all classes of engine. It is stated in the reply that the examination takes place every 4 and 7 years. This is not clear. Apparently the first internal examination takes place after 4 years and the succeeding ones after 3 years. The external examination always takes place when general repairs are carried out.

5. When an internal inspection is made, the tubes are removed, and the boiler is cleaned and examined. The reply does not state whether a water pressure test is applied. A distinction is made between internal and external examinations.

6. Tubes and defective stays are replaced. The boiler is repaired so far as is required. It is not stated in the reply whether other details, such as steam collectors, regulator steam pipes, feed heaters and feed details are tested. This information is generally lacking in the reports from foreign railways.

Dutch Indies State Railways.

I. *General repairs.*

1. The general repair depends on the condition of the boiler and driving gear, if heavy damage through accident does not demand it.

2. There are no legal requirements for the examination of the brake, those for the boiler and frames are given below.

3. Every boiler must be tested as often

as it is considered necessary for safety by the authority responsible for safety. That authority may modify existing requirements. An internal examination must be made at the latest 9 years after the boiler is put into service, it must be repeated at intervals of 6 years. Every 3 years an external examination of the boiler and the frame must take place. The firebox must be examined every two years.

4. The inspection periods are the same for all classes of engine.

5. For the internal examination boiler tubes and the steam pipes in the smoke box are removed and the boiler is examined thoroughly both internally and externally. During the external examination the boiler is examined so far as is possible. An hydraulic pressure test is applied in both cases. The test pressure is 3 kgr./cm² (14.6 lb. per sq. inch) above the working pressure. The pressure test is carried out after every heavy repair and the external examination is then dispensed with.

6. The following work is regularly carried out when the boiler is examined : renewal of the tubes (at internal examinations only) removal of tubes in the smokebox, renewal of wash-out plugs, cleaning of the boiler, renewal of defective stay bolts, renewal of defective crown stays with nuts, removal and refixing of details, repairs of cracks, removal and re-erection of superheater tubes.

Swedish State Railways.

I. *General repairs.*

1. The general repair depends on the state of the boiler and driving gear.

2. The conditions governing the treatment of the locomotive boiler, the frames, etc. are laid down by the State railway authorities. They differentiate between: general repairs with internal examination, minor repairs with internal examination and repairs without internal examination. The report does not state within what periods these examinations must be carried out.

3. The examinations, which must always take place with general repairs, are carried out after fixed mileages.

4. The mileages vary for the different classes of engine and engines are divided into 5 groups.

5. For general repairs with internal examination, fireboxes and tubes are removed and all internal parts are examined. For minor repairs with internal examination, the tubes are removed and the barrel and tube plates are examined. After repair the boiler is given pressure tests. On steam test, the test pressure must exceed the working pressure by 2 kgr./cm² (28.4 lb. per sq. inch) on water test by 5 kgr./cm² (71 lb. per sq. inch). These pressure tests take place after a repair without internal examination.

6. All repairs necessary for pressure tests. It is not stated if it is the rule to remove such other details as feed heaters, steam collectors and steam pipes, etc. for inspection and repair, at these tests.

Danish State Railways.

I. *General repairs.*

1. General repairs are carried out when tyres require re-turning. The deterioration of the boiler, frames and driving gear has then gone so far that a general repair is necessary.

2. Legal requirements for the treatment and examination of boilers, frames, tenders and brakes, exist.

3. Boiler examinations are carried out after a fixed period in the case of internal examinations only. This takes place for the first time 4 years after the boiler is put into service and is repeated at similar intervals. The frames and tender are examined at the same time.

4. The period between examinations is the same for all classes of engine.

5. At these examinations the tubes are taken out, the clothing is removed and the boiler is inspected both inside and out. After repair it is tested by hydraulic pressure. In this test the test pressure must exceed the working pressure by 5 kgr./cm² (71 lb. per sq. inch). The boiler test is repeated after every heavy repair. Any boiler showing permanent set under test or cracks of any importance must not be used in such condition.

6. In addition to the work necessary to carry out the pressure tests pressure gauges and safety valves must be tested.

Norwegian State Railways.

I. *General repairs.*

The Norwegian State Railways have no main shops. The engines are repaired almost entirely in the running shed repair works. There is however, a central shop which carries out the majority of the boiler repairs and makes the internal boiler examinations.

1. General repairs (repairs in the course of which the engine is lifted) depend on tyre wear and on the condition of the engine. Passenger engines are due for repair after a mileage of from 80 000 to 120 000 km. (50 000 to 74 570 miles) and express engines on light service, after about 200 000 km. (124 280 miles).

2. Legal requirements are in force for the treatment and examination of locomotive boilers; there are none for the frames, tender or brake.

3. Examinations take place after a fixed period. The first examination of a new boiler must be made after 100 months, it must then be repeated regularly after 75 months. The external examinations take place every 35 months.

4. The intervals between examinations are the same for all classes of engine.

5. For an internal examination, the tubes and if necessary the firebox are removed. The boiler is examined internally and externally and after repair is completed it is tested hydraulically. Measurements are taken to check alterations in shape of the barrel and firebox, due to this test. Pressure tests are made after external examination and heavy repair. The test pressure must exceed the working pressure by 50 % but must not be less than 14 kgr./cm² (199 lb. per sq. inch). The boiler clothing is not removed at external examinations.

6. Details of the work done for carrying out the pressure test have been omitted. It is also not stated what parts are regularly repaired.

Finnish State Railways.

1. *General repairs.*

1. The general repair is dependent on the condition of the boiler, the frames and the driving gear.

2. The treatment and examination of the locomotive boiler is governed by legal requirements; there are no rules for frames, brake etc.

3. Examinations take place after fixed periods. Internal examinations take place every 6 years and external examinations every 3 years. In addition, an external examination is made each year.

4. The periods between examinations are the same for all classes of engine.

5. At internal examinations the tubes and if necessary the firebox are removed, the clothing is taken off and the boiler is then carefully inspected both inside and out. For external examination the clothing is also removed and a few tubes are taken out and the boiler is externally, and so far as possible, internally examined. A pressure test with

water and steam completes both examinations. The report does not state what pressure is used. The yearly inspection takes place in the running shed repair works. The boiler safety valves and the mountings are tested on that occasion.

6. The necessary repairs are carried out for the pressure test, but the report does not say what details are regularly repaired for the test.

Swiss Federal Railways.

1. *General repairs.*

1. General repairs depend on the general condition of the engine.

2. Yes, the ordinances of the Swiss Federal Council.

3. The external examination is made after 3 years, the internal after 6 years.

4. No.

5-6. Existing defects are made good before the external examination. For the internal examinations all tubes are removed and if necessary the entire firebox overhauled. For the external examination the test pressure must exceed the working pressure by 2 atm. (28.4 lb. per sq. inch), and for the internal examination by 5 atm. (71 lb. per sq. inch).

German State Railways.

II. *Periodical examinations.*

1. The following work is regularly carried out on engines during their running life.

Washing out of the boiler, testing and polishing the boiler mountings. Examining the feed water for thightness. Testing for brake leakage. Examination of the steam distribution valves. Examination of the pressure equalizing valves (cylinder by-pass). Examination of the lighting turbo-generator. Examination of the mud separator according to the work done by the engine and the quality of the water. Intermediate examination of compressed brake. Examination of the pistons and stuffing boxes.

The periods are in part fixed by service orders and in part by the State Railway Divisions: they are arranged in accordance with the quality of the feed water and the mileage run by the engines. They are indicated in an instruction as to the periodical work.

2. The German State Railways estimate the increase in mileage output realized at as much as 25 %.

3. All minor defects are made good in the running shed repair works, i. e. such as arise from ordinary wear and tear in service. The most frequent repairs which are not mentioned under periodical repairs, are given in the statement attached herewith (see end of section II [periodical examinations]).

4. The enginemen do not take any share in repair work, but they are expected to take up bearings, screws, nuts and wedges and to make good small defects which occur on the trip.

5. The fitters in the running sheds work on day shift only. In the larger shops morning and afternoon shifts are worked. The early shift is then strongest. In addition a certain number of mechanics are brought in at night at the medium and larger shops.

6. In order to fix the number of mechanics required, figures the result of experience, have been got out for each class of engine. In addition, the local conditions, such as long runs, long stand-by periods and the equipment of the shop concerned, are taken into consideration.

7. All work that can be carried out on contract, that is to say an average of from 70 to 80 %, is so worked. Exceptions are the specialists such as turners, smiths, pressmen, etc. who are paid allowances of from 10 to 20 % in place of contract profits.

Other countries.

Madrid, Saragossa and Alicante. Railway Company.

II. *Periodical examinations.*

1. During the running life of the engine the boiler is washed out every 8 days (after a mileage of about 1 000 km. [621 miles]). If the engine runs on bad water the firebox crown plates are cleared of scale after 20 000 km. (12 400 miles). Otherwise only the defects notified by the driver are made good.

2. This question has not been answered.

3. Beyond washing out the boiler, only the defects notified by the driver are made good in the running shed repair shops. These are chiefly such as result from ordinary wear and tear and such as must be made good to make the engine capable of service and safe.

4. The enginemen take no part in the repairs.

5. Generally speaking only day shift is worked; a night shift is only worked in case of necessity. Special gangs of mechanics are not employed for night work.

6. It must be concluded from the answer that no special records are used to fix the number of manual workers required.

7. Day work is the usual system. Heavy repairs are carried out either by day work or contract payments.

North of Spain Railway Company.

II. *Periodical examinations.*

1. Pistons, valves, rod brasses and driving gear are regularly examined, but it is not stated at what intervals this is done. No remarks are made in respect to boiler washing out.

2. There are no statistical data on which to base an answer to this question.

3. Such running repairs are carried out in the running shed repair shops as are necessary to maintain the engines in safe and good running order. In addition such heavier work as changing wheels, small repairs to the firebox and repairs to the driving gear are also carried out.

It is evident, that here, it is a case of well equipped running shed repairs shops, as work is carried out which is commonly done in the main repair works.

4. The enginemen do not take part in repairs.

5. The majority of the work in the running shed repair shops is done on daily pay; a few night mechanics are available.

6. No figures are given in regard to fixing the number of workmen required.

7. Work in the running shed repair shops is carried out on the daily pay system.

Portuguese Railway Company.

II. *Periodical examinations.*

1. All important parts are periodically examined, in particular the pistons and valves. The periods have not been given, the washing out of the boiler is not mentioned.

2. It is not stated how far the regular examinations have raised the mileage run, but it is remarked that they have resulted in the reduction of the accidents in working by one third.

3. Urgent and running repairs are carried out in the running repair shops.

4. The engine crews take no part in repairs.

5. Day and night gangs are maintained

which undertake all urgent and running repairs.

6. The number of manual workers required is fixed in accordance with the number of engines working from a shed.

7. Both the day and contract systems are worked.

Beira-Alta Railway.

II. *Periodical examinations.*

1. Pistons and valves are examined after mileage output of about 20 000 km. (12 400 miles), the brakes, bearings, etc. as required. No periods between washouts are given.

2. Such works are important in order to obtain, between two heavy repairs, the before mentioned output and in order to reduce accidents and to prevent interruptions of traffic.

How far output is raised and interruption of traffic prevented, is not stated.

3. Minor defects due to wear and tear are made good in the running repair shops.

4. The enginemen are not employed on repair work.

5. Gangs of mechanics are only employed during the day. No night repair work is carried out.

6. The number of manual workers required is fixed in accordance with practical experience and as the nature of the repairs demands.

7. The daily pay system is worked.

Netherlands Railways.

II. *Periodical examinations.*

1. Pistons, valves, brakes and rod bearings are periodically examined during the running life of the engine. There is no fixed plan, the intervals at which examinations are made is not stated; nothing is said as to the washing out of boilers.

2. It is assumed that regular repair work assists appreciably to raise the mileage output between two heavy repairs and to prevent accidents.

3. The answer is : « Minor repair to the boiler, to the driving gear, to the bearing spring, etc. ».

It may be taken that here also the small repairs, due to every day wear and tear, are made good in the running shed repair shops.

4. The enginemen are not employed on repair work.

5. Repair of engines is only carried out by day.

6. The engine classes are valued by units. The sum of the units divided by 6 gives the number of the manual workmen required; this total is increased by a few men in order to carry out the periodical examination of pistons and valves.

7. The daily pay system is in force.

Dutch Indies State Railways.

II. *Periodical examinations.*

1. The following work is carried out once a month : pressure gauges examined, the safety valves reset, the boiler washed out, the dome being removed for the purpose, the boiler opened out, the regulator attended to, the firebox examined, injectors cleaned, the feed heater cleaned, the tender washed out and the tender feed valves attended to.

Every second month : high- and low pressure valves are reset, oil pump is cleaned, oil sprayers are cleaned, sight feed oiler oil pipes and blast pipe are cleaned, bolts, cranks, vacuum and hand brakes are seen to.

2. Periodical examinations help to raise the mileage between two general repairs and to bring to light, in good

time, small defects which are then remedied. It is not possible to estimate the result of these measures.

3. The running repair works are able to lift engines and change sets of wheels. As one week is required for this job, while a general repair can be carried out in 18 days and as the main shops are of sufficient size, engines requiring considerable repairs are taken to the main shops.

The report shows that, as a general rule, only the small running repairs are made in the running shed repair works, while the heavy ones are carried out in the main shops.

4. The enginemen are employed on repair work.

5. The answer to question 5 is « No ».

It can be gathered from the answer to question 6 that small running repairs are carried out by the enginemen. At any rate only a few if any, mechanics are available.

6. On the grounds stated in 5) no figures exist on which to base the number of manual workers required.

7. The enginemen receive fixed wages; it is not stated how the mechanics are paid.

Swedish State Railways.

II. *Periodical examinations.*

1. Four periodical examinations are undertaken between each two heavy repairs. They are fixed specially for each class of engine and are made after from 20 000 to 30 000 km. (12 400 to 18 600 miles) and are so arranged that the mileage between the third and fourth examinations is the lowest.

2. If tyres are turned at one of the major periodical examinations, the mileage run between two heavy repairs will often be increased by from 30 to 40 %.

3. The maintenance shops are linked up with the running shed repair shops. The latter generally carry out only the small running repairs. They take over bigger jobs, in the course of which the boiler is dismantled internally, when the maintenance shops are overloaded.

4. The enginemen do not engage in repairs.

5. The mechanics work on a fixed duty roster, which includes night work when such is required.

6. No special rules exist for fixing the number of manual workers required. Care is however taken that the number is kept as low as possible.

7. In the main shops, work, is as a rule, done on contract and in the running shed repair shops on day pay.

Danish State Railways.

II. *Periodical examinations.*

1. Every second month valves are cleaned and tested : the alternative months, fireboxes and smoke boxes are examined for accumulations of scale, etc., the water gauges, injectors and the brake valves are examined and put in order. Feed water heaters are examined and cleaned at intervals of three months; pistons are taken out every six months.

2. These inspections do not affect the intervals between the boiler repairs. The daily watch, kept by the enginemen, and the periodical examinations in the engine sheds, have the object of avoiding accidents during service. Information as to their estimated effect on the mileage between two heavy repairs, is lacking.

3. The main shops always carry out the examination of the boiler and turn wheels. Other repairs are carried out in the running shed repair works.

4. The enginemen take no part in repair work.

5. In the larger running shed repair works, firemen are on duty during the whole day and in some large ones, at

night also. As stated in (4) the enginemen do not handle repairs. From the answer to question 5, it can however be accepted that firemen take the place of night mechanics.

6. The number of manual workers depends on the local conditions. The report does not say how the number is arrived at.

7. The contract system is in force in the main shops and the day wage system in the running shed repair works.

Norwegian State Railways.

II. *Periodical examinations.*

1. There is no general programme for periodical examination. Pistons are usually examined once between two heavy repairs at which the engine is lifted. The valves and by-pass valves are examined after from 10 000 to 30 000 km. (6 200 to 18 600 miles) has been run, the rod brasses after 30 000 to 60 000 km. (18 600 to 37 200 miles). Fireboxes, grate, superheater elements and tubes are examined about twice as often as the valves and the pressure equalizing valves.

2. The importance of such work lies in the fact that it prevents accidents and delays.

If, and to what extent, the mileage between two heavy repairs is increased is not stated.

3. The Norwegian State Railways have no main works in the same sense as other railways. There is only a central shop, at which the internal boiler repairs are carried out. With the exception of this work, all repairs, as also the external examinations with pressure tests, are carried out in the running shed repair works.

4. The enginemen are only exceptionally employed on repairs.

5. When engine duty sheets require it, mechanics for night work are employed in isolated instances.

6. This question has not been answered.

7. Hourly wages are paid.

Finnish State Railways.

II. *Periodical examinations.*

1. Tyres are tapped and securing rings, bolts, nuts and the air inlet valves of the cylinders are examined every second week. Other bolts and screws, nuts and wedges and oil cups are examined, but are not taken adrift, unless defects are discovered. The filters of the oiling apparatus are drawn out and cleaned. At each wash-out, but after a minimum of 6 weeks, the springs are examined but are only taken down if defects are found. The rubbing faces of the spring gear and also the details of the axles and bearings and driving rods are examined. The boiler inspection covers are removed to facilitate washing out, the chimney, tubes, grate and fusible plugs are examined. It has previously been ascertained, while in steam, if the blower, blast pipe and turbine are working satisfactorily. To prevent throwing of sparks, during the period from the melting of the snow till October, all the screens in the ashpan, and the spark arrestors are examined at each wash-out, but at minimum periods of 6 weeks. The pistons and valves are examined every three months. The spring gear, piston- and valve rods are warmed up during this examination in order that hair cracks (especially in cotterways) may be more easily detected. In addition the pressure-gauges and safety valves are checked with a standard gauge.

2. Question 2 has not been answered.

3. The inspections carried out vide (1), and running repairs are made in the running shed repair works.

4. The enginemen are utilized to make repairs.

5. Special mechanics are not maintained for day- and night repairs.

6. Question 6) has not been answered.

7. Hourly wages are paid.

Swiss Federal Railways.

II. *Periodical examinations.*

1. The following are examined at fixed intervals : fireboxes, pressure gauges, safety valves, water gauges, tyre flanges, connecting- and coupling rods, valves, pistons and air pumps. The boiler is washed out as required.

2. Is not answered.

3. All small defects arising from wear and tear or otherwise, are made good in the running shed repair works.

4. No.

5. The work is done in the day. At night only one or two fitters are on duty, to handle the most necessary work.

6. The number of manual workers required is regulated by the number and size of the engines.

7. The manual workers receive a yearly wage fixed by law.

Appendix to Section II.

Statement of the repairs most frequently undertaken in running shed repair works.

Changing brake blocks.
Repairing brake hangers.
Changing pins in brake gear.
Overhauling driving- and tender brakes.
Securing axlebox keeps.
Taking up axlebox wedges.
Turning carrying wheel tyres.
Changing bogie springs.
Renewing spring adjusting screws.
Changing coupled- or driving springs.
Tightening tubes.
Changing tubes.
Making live steam pipe joint.
Making vertical pipe joint.
Milling joint of individual superheater elements, on the header.
Tightening flanges of superheater elements.
Straightening the smoke box door cross bar.
Taking out, straightening and replacing firebars.
Grinding the regulator pilot valve.
Renewing stays.
Grinding in and greasing both cocks of the water gauge, grinding test cocks.
Grinding in and greasing ashpan- coal, and smokebox drencher cocks.
Fitting new ashpan drencher pipe.
Grinding steam stop valve for air- or feed pump.
Grinding steam heating valve.
Repairing the steam stop valve for the lighting generator.
Replacing the connecting shaft of the speed indicator.
Repairing the oil pump.
Changing the glass of the oil pump.
Attending to the boiler feed valve and replacing it.
Grinding in the boiler check valve.
Attending to the sight feed oiler.
Repairing the high-pressure oil check valves.
Changing the coal drenching hose.
Renewing the fire door protector plate.
Straightening the ashpan door rods.
Repairing the suction and delivery valves of feed pump.
Changing the air pump.
Repairing the air pump pressure regulator.
Changing the water piston rings of feed pump.
Changing the injector.
Changing feed heater.
Making joint of the feed heater change over cock.
Tightening up valve chest cover.
Lining up crosshead.
Gauge slidebars, reset.
Repair crosshead oilbox.
Change needle guide of rod bearing oiler.
Remetal rod brass.
Remetal piston tailrod bush.
Grind cylinder valves.
Change drawhook spring.
Repair tender water gauge.
Test and tighten gas pipes.

German State Railways.

III. *Minor examinations.*

1. When removing wheels, which will be mentioned in connection with intermediate repairs, it is usual to examine pistons, valves and regulators, it may subsequently happen that an intermediate repair is rendered necessary by sudden damage such as a broken tyre or an accident, while valves, pistons and regulators have only lately been examined. Other small repairs are carried out in connection with such small repairs, as may be required.

2. Such work is mainly done by the main repair works but is, in so far as they may be suited for it, sometimes made over to the running shed repairs shops.

3. About 10 to 11 days, including running to and from the repair works.

4. The German State Railways credit the first intermediate repair with 20 %, the second with 10 % and the third with 5 % of the total mileage.

5. Should an intermediate repair have to be undertaken, from 6 to 9 months before the due date of a boiler examination, then the latter will be carried out that much earlier, if the condition of the boiler demands it.

6. No.

7. In the case of engines with interchangeable wheels, the leading wheels are only changed, if its flanges are more worn than those of the other wheels of the set.

8. Express- and passenger engines are run down after about 1 1/2 to 2 years. Goods engines require heavy repairs usually after 2 years while shunting engines frequently run 3 years.

The object of the intermediate examination, which principally deals with axleboxes and tyres, is to so extend the running life of the engine that it only requires heavy repairs at the date on which legal heavy repairs or examinations are due.

9. The axle- and rod bearings, as also the tyres have considerable influence on the increase of mileage. Lubrication of cylinders and valves is also of importance. If the boiler is regularly washed out and remains clean it will run for the period prescribed by law.

Madrid, Saragossa and Alicante Railway Company.

III. *Minor examinations.*

1. Intermediate repairs, during which the tyres are turned and the axle bearings are repaired, are not carried out between two heavy repairs. Pistons, valyes and regulators are only examined on demand by the driver.

2-3. The answer to questions 2) and 3) refers to general repairs.

4-5. In reply to these questions it is again stated that intermediate repairs are not carried out.

6. No.

7. In the case of some engines of an 8-coupled type, the leading wheels are interchanged with the 4th pair when the engine has completed 50 % of the mileage anticipated between two heavy repairs.

8. No intermediate repairs are carried out and therefore the heavy repair, if it is carried out on completion of 100 000 km. (62 100 miles), is carried out at the same time as the major examination, there is therefore no alteration of the heavy repair in the sense of question 8.

9. The firebox and chiefly the tube plate.

North of Spain Railway Company.

III. *Minor examinations.*

1. Pistons, valves and regulator are regularly examined during intermediate repairs.

2. In the running shed repair shops.

3. During 1930, 26 days were occupied by an intermediate examination.

4. This question has not been answered.

5. In regard to this it is reported : « Such a case has not yet occurred. »

From the answer to question 4) of section I, it appears that the engines receive one heavy repair per year, and this is completed with a pressure test. They are taken to a repair works. The intermediate repairs are here of the nature of general repairs. For the foregoing reasons, the case mentioned in question 5 cannot arise.

6. No.

7. No.

8. Because of liability mentioned under 5) there is no necessity to antidate the repair.

9. The journal brasses, the axleboxes, the running gear, etc.

Portugese Railway Company.

III. *Minor examinations.*

1-8. It is clear from the answers to (1 to 8) that intermediate repairs are not undertaken. The answers refer rather to general repairs and to boiler examinations.

9. Proper upkeep of the tyres and bearing brasses is of the greatest importance in the direction of increasing mileage.

Beira-Alta Railway Company.

III. *Minor examinations.*

1. The valves, pistons and regulators are examined during intermediate repairs and also such other work, as may be necessary, is done.

2-3. In the general shops. Whether the running shed repair works or a repair works is meant cannot be clearly established. Apparently the latter, as the duration of an intermediate repair is stated in 3) to be 30 to 40 days. It is therefore a case or a repair that from the commencement must be called a general repair.

4. Question 4 has not been answered, but it is reported that a minor repair is undertaken after 60 000 km. (37 300 miles) and a heavy repair after 120 000 m. (74 570 miles).

5. The reply to this is that the question must be dealt with and solved for each individual case. What the solution is, is not stated.

6. No.

7. No.

8. The periods between general repairs cannot be extended as tubes and smoke tubes will not last long enough.

9. Boiler tubes.

Netherlands Railways.

III. *Minor examinations.*

1. Yes, pistons, valves and regulator are regularly examined.

2. In the running shed repair works.

3. Minor examinations, during which tyres are turned, do not generally take place.

4. The answer to question 4 is : «Unknown ».

5. The answer to 5) is: « That depends on the conditions ». No conclusion can be drawn from this answer.

6. No.

7. Yes.

8. Heavy repairs are usually carried

out once a year. As in accordance with the answer to question 3, the tyres are not turned during intermediate repairs, any extension of the interval in the sense of question 8 is not possible.

9. The details of the driving and running gear.

Dutch Indies State Railways.

III. *Minor examinations.*

1. Yes, the pistons, valves, regulators and other important parts are regularly examined during the intermediate examinations.

2. In the running shed repair works.

3. At most one week.

4. The answer to this question is : « Unknown ».

5. In regard to question 5 it is reported : « That has no influence ». This contention is not explained. If as mentioned in I-3 the heavy repairs are carried out after a fixed mileage or after a fixed interval, then, the condition mentioned in question 5 must frequently crop up.

6. No.

7. No.

8. It is not anticipated that the general repairs will be carried out more seldom as a number of the engines are already old.

9. Generally speaking, driving gear and fireboxes. The bearing metal of the driving and coupled axles of certain engines of the 2-10-2 type exercises a controlling influence.

Swedish State Railways.

III. *Minor examinations.*

1. Yes.

2. In the main repair shops.

3. An intermediate repair usually takes 10 to 15 days. If it is necessary to re-turn tyres, then it is usual to carry out heavy repairs.

4. From 30 to 50 %.

5. If the heavy repair must be undertaken from 6 to 7 months before the periodical examination of the boiler is due, then as a rule, the boiler examination is carried out at the same time.

6. No.

7. No.

8. The condition foreshadowed in 8) cannot occur, in that the heavy repair is carried out without reference to time, but on the completion of a given mileage, and the boiler examination is linked with it.

9. Driving gear, axle journals of the driving axles and tyres.

Danish State Railways.

III. *Minor examinations.*

1. Yes.

2. In the main shops.

3. About 14 days.

4. This question is not answered.

5. In that event the boiler examination will be carried out about 6 to 8 months earlier.

6. No.

7. No.

8. On the grounds given under 8) the Administration is endeavouring to raise from 3 years to 4 years, the interval between internal boiler examinations.

9. The firebox and wheels.

Norwegian State Railways.

III. *Minor examinations.*

1. Regular intermediate examinations are not carried out. Pistons are usually examined once between each two heavy repairs or after 10 000-30 000 km. (6 200 to 18 640 miles).

2. The work is done in the running shed repair works.

3. Is not answered, as intermediate repairs are not undertaken.

4. This question is not answered.

5. This condition does not occur. The engines cover standby or other light duty, during the last period before the periodical boiler examination.

6. No.

7. No, the flanges of the most tyres are rounded off and the wheels can then be run until the next heavy repair.

8. Question 8 is not answered.

9. Tyres and axleboxes with horn blocks.

Finnish State Railways.

III. *Minor examinations.*

1. Yes.

2. In the main repair shops.

3. About one week.

4. Perhaps 50 %.

5. The answer reads : « The boiler may be tested 6 weeks or less before the date laid down by law.

As a result of this it may occur that the engine which requires repairs must be laid up till the time for the next examination arrives or it must be repaired and then cannot be fully run down before the next examination must be made.

6. No.

7. No.

8. No answer is given.

9. The wheels and their proper position in the frame, as also the correct length between the coupling rod centres.

Swiss Federal Railways.

III. *Minor examinations.*

1. Pistons, valves and regulator are only examined during an intermediate repair in the main repair shops, at the request of the running shed repair works concerned.

2. In the main repair works.

3. As an average in 15 days.

4. About 33 %.

5. The examination will be carried out earlier.

6. No.

7. Interchangeable wheel sets with worn flanges are interchanged with each other.

8. Engines receive an intermediate repair after 1 1/2 years and an external examination after 3 years. This practice cannot be departed from unless the existing ordinances are altered.

9. The tyres as also the axle- and the rod bearings have the largest influence on increase of mileage. Cylinder- and valve lubrication is also important.

German State Railways.

IV. *Materials, design, etc.*

1. The tyres are rolled from special steel with a tensile of 80 to 92 kgr./mm² (50.8 to 58.4 Engl. tons/in.²).

The tensile corresponding to the Brinell test of hardness of all the tyres of a complete set of driving and coupled wheels should not differ by more than 6 kgr./mm² (3.81 Engl. tons/in.²).

The tup falling vertically on the tread of the tyre shall produce a depression in accordance with the formula $f = \frac{75 \cdot d}{100 \sigma_B}$.

In this formula f represents the depression in hundredths of the internal diameter, d the diameter on the tread of the finished tyre, σ_B the before mentioned minimum tensile in kgr./mm². During the test the tyre must not fracture nor show any other defect. The moment (product of the height of drop and the weight of the tup) of a

blow shall equal $M = 15\ G$, wherein M represents the moment in kilogrammetres, and G the weight in kgr. of the tyre as rolled.

The temperature of the test piece must be taken and recorded before the test.

Rails shall have a minimum tensile of 70 kgr./mm² (44.4 Engl. t./in.²). The steel shall be so tough that with points of support 1 m. (3 ft. 3 3/8 in.) apart, rails with a minimum of 70 kgr./mm² can be bent 90 mm. (3 1/2 inches) without breaking or cracking.

Rails are as a rule struck on the head. The test piece is about 1.30 m. (4 ft. 3 3/16 in.) in length. The supports on which the rail is placed must be semicircular in shape with a radius of 50 mm. (2 inches).

For rails weighing 40 kgr. per m. (80.6 lb. per yard) and over the moment of blow must be 5 000 Kgr.-M. (36 165 ft.-lb.). Further blows must be struck with moments of 3 000 Kgr.-M. (21 700 ft.-lb.) until the previously mentioned deflection is obtained. The weight of the last blow can be regulated to give the final amount of deflection required.

The amount of deflection at each blow and the temperature of the test room must be taken and recorded.

2. The part of the running surface of the rail touched by the tyre must be sufficiently large to keep the unit pressure, and therefore the wear comparatively small. This applies also to the flange and to the rail on curves.

3. Studies have been made but full tests have not yet been completed.

4. Up to 25 mm. (1 inch) on tread. (The tread circle is the circle drawn at a point on the tread, which is cut by a line drawn parallel to, and 70 mm. (2 3/4 inches) from the inner face of the tyre).

5. No.

6. The stuffing box which has proved most satisfactory, which has cost the least, and which is used on all superheated engines, consists of two cast iron semi-circular shells with three chambers in which the packing rings lie. These are also made of cast iron which is specially produced for this purpose; they last for at least 200 000 km. (124 000 miles). These rings require no maintenance.

7. The axle and rod bearings are made of bronze, lined with white metal. The bronze is constituted as follows: Copper 85, tin 9, and zinc 6 parts. The white metal consists of: tin 80, antimony 12, copper 6, and lead 2 parts.

8. Bad feed water will always affect the mileage run between two repairs adversely. How far it does so, will depend on the measures taken to reduce or repair the damage caused. Nearly all engines are equipped with mud separators. That most commonly in use is fitted in a special feed dome and consists of a number of angle irons, which are laid one above the other. The water is injected into the dome in the form of a fine spray and falls through the hot steam space on to the angles and being rapidly heated, throws down some of the scale-forming elements, which settle on the angles. The water is then carried through sheet steel channels round the outside of the tubes to the bottom of the boiler barrel where further scale is deposited. Blow out arrangements are fitted above the firebox foundation ring and below the mud separator, in the shape of valves. The mud is blown out each day by means of these valves under steam pressure. Engines which have to work with bad feed water are very carefully and often washed out.

In addition to the mud separators, water purifying plant is installed locally where very hard water is used.

These work chiefly on the lime-soda and soda-baryte systems. In these

plants the scale forming matter is separated from the water while cold. These plants are expensive and can only be recommended where the consumption of water is large. If they are to give satisfaction, they must be of ample size.

Where the consumption of water is small, scale removing compounds are used. With this system all the scale thrown down remains in the boiler, so far as it is not blown out through the mud separating arrangements.

9-*a*) The cylinders of superheated engines are lubricated with superheat oil; those of saturated steam engines with cylinder oil, suitable for saturated steam.

For superheated engines the oil must comply with the following conditions:

It must be free from sediment and other insoluble matter, free from mineral acids, it must not appear black under direct light.

Its specific gravity must be below 0.96 at 20° C. (68° F.).

Flash point in open vessel, over 300° C. (572° F.).

Viscosity (Engler), at 100° C. (212° F.), above 5.

Hard asphalt, below 0.1 %.

Acid content, below 0.7 %.

Ash, below 0.1 %.

Water, below 0.2 %.

Oil is fed to the cylinders of superheated engines by means of oil pumps, driven off the coupled axles, each pump having from 6 to 12 plungers, according to the design of the engine, of which each delivers an equal quantity of oil to two oiling points. Oil non return valves, to prevent the oil pipes becoming empty when the engine is standing or running light. These check valves only open when the pumps have raised the pressure in the oil pipes to from 20 to 40 atm. (284.5 to 569 lb. per sq. inch). Whilst similar pumps are used on saturated steam engines, large numbers of displacement oilers are also used. These latter lubricators utilize the boiler pressure to deliver the oil, in the form of a fine spray, to the points at which it is required;

b) Axle-boxes and rod bearings are lubricated with a mineral oil, which must comply with the following conditions:

It must be free from sediment and other insoluble matter and from free mineral acids.

Its specific gravity must be below 0.95 at 20° C. (68° F.).

Flash point in open vessel, over 300° C. (572° F.).

In the case of winter oil, 140° C. (284° F.).

Viscosity (Engler):

	Summer oil.	Winter oil.
at 20° C. (68° F.)	40 to 60	25 to 50
at 50° C. (122° F.)	7 to 10	45 to 80

Hard asphalt, below 0.2 %.

Acid content, below 4.2 %.

Water, below 0.2 %.

Summer oil must be fluid at -5° C. (23° F.) and winter oil at -20° C. (-4° F.).

Axle bearings are usually oiled by pads, but a few of the newer express engines have been experimentally fitted with a central oiling system, in which the oil is forced to the bearings by pumps. The rod bearings are oiled by means of pin trimming, thicker or thinner pins being used according to the viscosity of the oil. On some of the older engines, cylindrical pins from 7 to 9 mm. (9/32 to 3/8 inch) in diameter are used, these are flattened on one side to permit the oil to pass. When running, the oil is thrown against the needles or pins as the case may be, and is thus delivered to the bearings. When the engine is at rest no oil is fed.

10. Lately mechanical oiling has been extended to the pistons and piston rods of the feed and air pumps.

11. Mechanical lubrication is reliable and economical. The additional pump

required for central lubrication, if fitted in the cab, takes up much space and the whole arrangement is costly, so that the axles of the last express engines have been equipped with lubricator pads.

12. Almost all engines are fitted with wheel-watering fittings to reduce the wear of tyres. These are brought into operation by the staff before entering curves and spray the flange of the leading tyres.

Lately trials have been made with the application of grease to the radii of the flanges. Experiments have also been made in greasing the rails where the radii of the tyres make contact.

13. Only on specially bad curves.

14. So far a really usable and workable design has not been discovered.

Madrid, Saragossa and Alicante Railway Company.

IV. *Materials, design, etc.*

1. The following conditions govern the quality of tyres supplied : The tyres must be forged from rolled steel bars, which have been cast by the Siemens-Martin or Bessemer process. Tensile strength 70 kgr./mm² (44.4 Engl. t. per in.²); elongation 14 % measured on a length of 115 mm. (4 1/2 inches). The quality must be proved by the following drop test : The tyre must be placed on a solid foundation and must receive 4 consecutive blows from a falling weight without breaking or showing any crack. The weight of the tup to be 1 000 kgr. (2 200 lb.) and the height of drop 8 m. (26 ft. 3 in.).

Rails must be rolled from steel with a tensile strength of at least 72 kgr. (45.7 Eng. t. per in.²) and minimum elongation of 10 %.

In addition, tensile and elongation together must satisfy the furmula $R + 2A = 95$, the figure for the tensile strength being used for R and that for the elongation for A. The rails also have to pass Brinell, bending and drop tests.

Bending test. — 2 pieces 1.50 m. (4 ft. 11 in.) long must be cut from each rail at a point indicated by the Company's inspector ; one of these pieces will be placed in the running position on two supports and will be subjected to the following tests :

Weight of rail.	Distance between supports.	Pressure lasting for 5 minutes, applied midway between supports without permanent set.	Load lasting 5 minutes midway between supports without bending beyond 25 mm.	Maximum load without fracture : load to be applied gradually.
kgr. per m. *lb. per yard*).	m. (*ft.-in.*)	kgr. *lb.*	kgr. *lb.*	kgr. *lb.*
45 (90 7)	1 m. (3ft. 3 3/8 in.)	32 900 (72 500)	72 000 (158 700)	78 000 (171 900)
40 (80.6)		26 500 (58 400)	55 000 (121 200)	65 000 (143 300)
32.5 (63 5)		21 500 (47 400)	44 000 (97 000)	52 000 (114 600)

Drop test. — The second piece of rail 1.50 m. (4 ft. 11 in.) long must be placed on two supports, which are fastened to an anvil. Blows will be struck in the center, as given in the following table, and must be sustained without fracture occurring.

Weight of rail, per m.	Distance between supports.	Weight of anvil.	Weight of tup.	Height of drop.	
				3 m. (9 ft. 10 1/8 in.) without sustaining permanent set above :	6 m. (19 ft. 8 1/4 in.) with a maximum bend of :
45 kgr.	1.10 m. (3 ft. 7 5/16 in.)	10 000 kgr. (22 000 lb.)	300 kgr. (660 lb.)	0.010 m. (25/64 in.)	0.030 m. (1 3/16 in.)
40 »				0.015 » (19/32 in.)	0.040 » (1 37/64 in.)
32.5 »				0.019 » (3/4 in.)	0.050 » (1 31/32 in.)

2. As a matter of principle the material of the rails should be harder than that of the tyres.

3. No.

4. Tyres of braked wheels may be worn to 36 mm. (1 7/16 in.) those of unbraked wheels to 32 mm. (1 1/4 in.)

5. No.

6. Stuffing boxes with white metal packing rings are in use and give satisfaction.

7. Axlebox- and rod bearings are made of bronze consisting of : 81.5 % copper, 14.5 % tin, 4 % phosphate of copper (containing 8.5 % phosphorous). They are filled with white metal consisting of : 84.66 % tin, 9.34 % antimony, 6.00 % yellow metal (made of 65 % copper and 35 % zinc).

8. The quality of the water exercises a considerable influence on the maintenance of fireboxes and therefore on the mileage between two heavy repairs. In order to obtain the mileages mentioned above, it is the practice to purify bad feed water chemically with lime and soda or soda lye.

9. Three kinds of lubricating oil are used :

a) Oil for driving gear ;

b) Valvoline for superheated steam;

c) Valvoline for saturated steam.

The superheater oil *b*) must comply with the following conditions :

It must be free from foreign matter and from mineral acids, there must be no deposit after 48 hours. After heating to 360° C. (700° F.) for 2 hours, the loss in weight must not exceed 2 %.

Specific gravity at 15° C. (59° F.), 0.890 to 0.910.

Flash point in open crucible, over 325° C. (617° F.).

No hard asphalt content.

Ash, below 0.05 %.

Water, 0.

Viscosity (Barbey) :

at plus 35° C. (95° F.), 3 to 10,
» 100° C. (232° F.), 60 to 90,
» 200° C. (412° F.), max. 900.

Valvoline for saturated steam must be free from free mineral acids and other impurities.

Specific gravity at 15° C. (59° F.), 0.9 to 0.915.

Flash point, not below 240° C. (464° F.).

Viscosity (Barbey) :

at plus 35° C. (95° F.), 10 to 15,
» 100° C. (232° F.), 175 to 225,
» 200° C. (412° F.), max. 1400.

The axle bearings are lubricated by oil pads, the rod bearings by pin trimmings. Cylinders are oiled either by pumps or by pressure lubricators.

10. Mechanical lubrication is only

used on a few classes of engine and then only for the pistons and valves. As a rule pressure lubrication is used.

The answer does not make clear what is meant by pressure lubrication. Possibly a displacement lubricator is meant.

11. Mechanical lubrication offers no advantages; on the contrary there are certain disadvantages in winter as a result of the high viscosity of the oil.

12. Wheel flange lubrication has been tried experimentally on engines running on sections having numerous curves of small radius.

13. Lubrication reduce the wear of the flanges.

North of Spain Railway Company.

IV. *Materials, design, etc.*

1. The French specifications for the supply of tyres and rails are in force.

2. Wheel and rail should be so constituted that the minimum of wear takes place on both.

3. No.

4. The tyres of braked engine wheels may be worn to 37 mm. (1 9/64 inches), those of unbraked wheels to 29 mm. (1 3/8 inches) and tender wheels to 35 mm. (1 29/64 inches).

5. No.

6. The superheated express engines are fitted with Schmidt stuffing boxes. Trials are being carried out with stuffing boxes of the Garex, Liard and Hauber designs.

7. The bearing metal for axle- and rod brasses is made from 85 % tin, 5 % copper, 10 % antimony.

8. Bad water increases boiler repairs and reduces the mileage between two heavy repairs. In the Mediterranean areas, scale removing composition is used.

9. The cylinders of superheated engines are oiled with superheated steam oil and those of the saturated steam engines are oiled with an oil suitable for saturated steam.

Axle boxes- and rod bearings are lubricated with a special oil which is supplied in summer and winter grades.

Cylinders are oiled by pumps of the Detroit, Friedmann and other types; axles are lubricated with oiler pads : some Isothermos boxes are also in use. Rod brasses have worsted trimmings.

10. Mechanical lubricators are only in use on a few modern engines.

11. Mechanical lubrication is satisfactory and convenient.

12. The flanges of electric locomotives alone are lubricated.

13. The answer to this question is : « No ». It may be taken therefore that the lubrication of flanges is only carried out on specially bad sections.

14. Lubrication reduces the flange wear.

Portuguese Railway Company.

IV. *Materials, design, etc.*

1. French material specifications are in use to control the materials supplied.

2. The question is not answered.

3. No.

4. The question is answered : « A hollowing of 5 mm. (3/16 inch). The minimum permissible thickness of tyre is not given.

5. No.

6. The Huhn type is used and seems to work well. This seems to refer to the German State Railways' type of stuffing box with cast iron packing rings.

7. Bronze bearings with white metal insets. The bronze composition is not

given. The white metal for passenger engines is made up of : 5.55 % copper, 11.12 % antimony, 83.33 % tin.

That for goods engines consists of : 3 % copper, 14.5 % antimony, 40 % tin, 42.5 % lead.

8. Yes, very greatly. Feed water containing free oxygene is used, wich corrodes the tubes very seriously. For that reason, feeding with hot feed is being tried (the report does not give any explanation in respect to this reply).

9. The cylinders of superheated engines are oiled with an oil with a flash point of 350° (662° F.); crude oil is used for the saturated steam engines.

10. Question 10 is not answered. (From the answer to question 11, it can be concluded that cylinders and valves are in part oiled by mechanical lubricators (pumps).

11. Reliable oiling and maximum economy.

12. No, it is nevertheless intended to make trials.

Beira-Alta Railway Company.

IV. *Materials, design, etc.*

1. French material specifications are in force for the supply of materials.

2. Experience is not such as to admit of the question being answered.

3. No.

4. Braked engine wheels 40 to 50 mm. (1 9/16 to 1 31/32 inches); bogie wheels 30 mm. (1 3/16 inches).

5. No.

6. Experiments are being made with the Huhn stuffing box; the period of test is as yet too short to give any judgment.

7. Metal, according to German State Railways' specifications, is used for axle- and rod bearings.

8. The quality of the feed water on our lines is satisfactory; purifying plant is therefore not in question.

9. *a*) Suitable oil is used for cylinder lubrification, it is delivered to the parts to be oiled by oil pumps of the Friedmann design;

b) The axlebox- and rod bearings are oiled by hand oilers with a special oil.

10. Mechanical lubrication is generally used for pistons and valves.

11. Reliable oiling, maximum economy.

12. No.

Netherlands Railways.

IV. *Materials, design, etc.*

1. The material for locomotive tyres has a tensible of from 80 to 92 kgr./mm² (50.8 to 58.4 Engl. t. per in.²), with elongation coefficient of 8 %. No figures are quoted for rails.

2. Unknown.

3. No.

4. Not accurately laid down. Generally the wear is not more than 6 mm. (15/64 inch).

This means the permissible extent to which the tyres may wear on the tread. The minimum permissible thickness is not stated.

5. No.

6. The usual stuffing boxes are also used in the case of superheated engines.

7. The axlebox- and rod bearings are made of bronze, they are filled with white metal. The bronze is made of copper 85 %, tin 14 %, zinc 1 %. The white metal is made of copper 6 %, tin 84 %, antimony 10 %.

8. No; the boiler is washed out every 5 or 6 days.

9. *a)* The cylinders are oiled with spe-

cial oil suitable for superheated steam fed by oil pumps.

b) The axlebox- and rod bearings are fitted with worsted trimmings and are oiled with mineral oil.

10. Mechanical lubrication is only used for the cylinders.

11. Results are good.

12. No.

Dutch East Indies State Railways.

IV. *Materials, design, etc.*

1. The tyres supplied are to be of Siemens Martin steel, electrolytic or crucible steel. The tensible strength must be at least 80 kgr./mm² (50.8 Engl. t. per in.²) with 13 % elongation measured on a test piece 100 mm. (3 15/16 inches) long and 20 mm. (25/32 inch) diameter. Rails are to be of Thomas steel, tensile strength from 65 to 75 kgr./mm² (41.3 to 47.6 Engl. t. per in.²) minimum, index of quality 900 (index = tensile strength × elongation).

2. Not known.

3. No.

4. Engine tyres may be worn down to a thickness of 45 mm. (1 49/64 inches).

5. The normal tyre profile is satisfactory for speeds up to 100 km. (62 miles) per hour.

6. Both Schmidt and Huhn stuffing boxes are in use and are satisfactory.

7. The metal used for axlebox- and rod bearings is made up as follows: tin, 75 %; antimony, 15 %; copper, 7 %; lead, 3 %.

8. Bad feed water is only encountered in a few places. Engines only take water at these places in exceptional circumstances. The water from the other stations leaves no deposit, so that mileage is not influenced by bad feed water.

9. The superheated cylinders are oiled with superheater cylinder oil EOS; the saturated cylinders with Transcontinental saturated oil; the axle and rod bearings are oiled with mark HOA 25 oil.

—	Mark Transcontinental.	Mark EOS.	Mark HOA 25
Specific gravity at 30° C. (86° F.)	0.92	0.91	0.97
Viscosity 50° C. (122° F.)	65.7	112.—	25.4
Viscosity 100° C. (212° F.)	5.78	9.2	2.45
Viscosity 150° C. (302° F.)	...	2.58	...
Flash point, Pensky Martens method, in closed vessel	260° C. (500° F.)	306° C. (582° F.)	227° C. (421° F.)
Boiling point	338° C. (640° F.)	381° C. (717° F.)	279° C. (536° F.)
Flash point, Marcusson method, in open vessel	271° C. (518° F.)	332° C. (627° F.)	216° C. (411° F.)
Ash	0.09 %	0 12 %	...
Asphalt	0.73 %	...	...
Clearness	Nearly clear.	Nearly clear.	Clear.
Evaporation loss in 2 hours at 300° C. (572° F.)	0.34 %	0.9 %	...

11. The question is not answered.

12. No.

Swedish State Railways.

IV. *Materials, design, etc.*

1. The tyres must be made of Swedish Martin steel. The content in phosphorous shall not exceed 0.045. Tensile strength 72 kgr./mm² (45.7 Engl. t. per in.²), elongation 16 %. Rails must not contain more than 0.075 % phosphorous. Tensile strength 75 kgr./mm² (47.6 Engl. t. pàr in.²).

2. Is not known.

3. No.

4. To 35 mm. (1 3/8 inches).

5. No.

6. Stuffing boxes with while metal packings.

7. White metal is used for axlebox- and rod bearings, the composition being: 80 % tin, 13 % antimony, 7 % copper.

It is not stated if bronze bearings are also used.

8. Yes, in southern Sweden the feed water is so bad that boilers suffer badly and the periods between two heavy repairs have often to be reduced on account of damaged boilers. The usual purifying methods are employed to reduce the bad influence of hard water. (What these arrangements are, is not mentioned in the reply).

9. *a*) The oil must fulfil the following conditions :

Superheater oil :

Viscosity (Engler), up to + 100° C. (212° F.), at least 7.5; flash point (Marcusson), at least 320° C. (608° F.),

b) Oil for axleboxes :

Viscosity up to + 50° C. (122° F.) at least 5.5.

Flash point (Pensky-Martens), at least 170° C. (338° F.).

Friedmann or Dicker & Werneburg lubricators are in use. The latest engines are fitted with a Swedish oiler, « Assa » type.

10. No. Only for the cylinders and valves of the superheated engines.

11. Safer lubrication, less oil consumption.

12. No.

Danish State Railways.

IV. *Materials, design, etc.*

1. The tyres shall be made throughout from the best and most uniform, defect-free Siemens-Martin steel from weldless forged and rolled rings. Tensile strength 75 kgr./mm² (47.6 Engl. t. per in.²); elongation 12 %.

Rails must be rolled from best quality steel. Tensile from 70 to 80 kgr./mm² (44.4 to 50.8 Engl. t. per in.²) and elongation, 12 % minimum.

2. Question 2 is not answered.

3. No.

4. Tyres, after the last turning must be 25 mm. (1 inch) on the tread, the greatest wear permitted on engine tyres, on the tread is 7 mm. (9/32 inch).

5. No.

6. The question is not answered.

7. Bronze and H-metal are used for axlebox bearings. The composition is :

	Bronze	H-metal
Copper . . .	80 %	5.5 % or 10 %
Lead. . . .	10 %	3.0 % » —
Tin	10 %	80.0 % » 80 %
Antimony. .	—	11.5 % » 10 %

8. Feed water is purified.

9. *a*) The cylinders and valves of superheated engines are oiled by Friedmann and Wakefield pumps, a superheater oil being used.

b) Axlebox- and rod bearings are fitted with pad oilers; they are oiled with mineral.

10. Mechanical lubrication is used for cylinders and valves only.

11. Reliable lubrication and economical use of lubricant.

12. No.

Norwegian State Railways.

IV. *Materials, design, etc.*

1. The tyres shall be made in the form of weldless rings from defect-free cast blocks, by forging and rolling. Tensile 80 to 92 kgr./cm² (50.8 to 57.2 Engl. t. per in.²); 8 to 10 % on a test length equal to 10 times the diameter of the test piece.

Rails must have a minimum tensile strength of 70 kgr./mm² (44.4 Engl. t. per in.²) with an elongation of 12 %.

2-3. The questions have not been answered because trials have not been made.

4. No general orders exist in regard to this.

5. No.

6. In the last few years, stuffing boxes with cast iron packing rings have been tried. The period of test is still too short to admit of any system being singled out as best.

7. Bearing bronze and white metal.

Bronze consists of : copper, 84 %; tin, 15 %; zinc, 1 %.

White metal, of : tin, 82 %; copper, 9 %; antimony, 9 %.

8. No, generally speaking the feed water is good and deposits little scale.

9. The cylinders and valves of superheated engines are oiled by oil pumps. Well filtered mineral oil is used, with which as a rule 6 % of grease is mixed. its specific gravity is 0.9 and below; flash point in open vessel, up to 285° C. (545° F.) and, in closed vessel, 251° C. (484° F.); low flash points are not permitted.

Mineral oil is used for lubricating the axlebox- and rod bearings and it must fulfil the following conditions :

Specific gravity, 0.9 to 0.94;

Viscosity (Engler), at 20° C. (68° F.), 60 to 35;

Viscosity (Engler), at 50° C. (122° F.), 8 to 6.5;

Flash point (Pensky-Martens), above 110° C. (230° F.);

The oil must still be fluid at 10° C. (50° F.).

10. Mechanical lubrication is in use for cylinders and valves and, on a few engines, for axleboxes; wick oiling is generally used.

11. The mechanical lubrication is reliable and economical.

12 to 14. On one section both rails and tyres are being greased experimentally. The rails are greased by hand. It appears that the wear of the parts has been reduced. Figures cannot, however, as yet be given.

Finnish State Railways.

IV. *Materials, design, etc.*

1. Tyres must be rolled from the best quality steel. Tensile strength, 70 kgr./mm² (44.4 Engl. t. per in.²) with elongation of 18 %.

Rails must be made from cast steel. The phosphorous content must not exceed 0.08. The tensile strength must be 70 kgr./mm² (44.4 Engl. t. per in.²) minimum. The product of tensile strength in kgr. × elongation in % must give 900.

2. This question is not answered.

3. No.

4. Up to 32 mm. (1 17/64 inches).

5. No.

6. Stuffing boxes with soft metal packings.

7. The metal used is composed as follows : tin, 85 %; antimony, 10 %; copper, 5 %.

8. Question 8 is not answered.

9. *a*) Cylinders and valves are mechanically oiled, a superheater oil with a flash point of 320° C. (608° F.) is used.

b) Axle- and rod bearings are oiled with a mineral oil with a flash point of 175° C. (347° F.). It is not stated whether wick or pin oilers are generally used.

10. Mechanical lubrication is only used for the valves and cylinders.

11. Question 11 is not answered.

12. No.

Swiss Federal Railways.

IV. *Materials, design, etc.*

1. The tyres of driving, coupled and carrying wheels are made of hard Martin steel with a tensile strength of 70 to 80 kgr./mm² (44.4 to 50.8 Engl. t. per in.²) and 13 % elongation; the tyres for tender wheels are made from hard Martin steel with tensile strength of from 63 to 68 kgr./mm² (40 to 43.2 Engl. t. per in.²) and elongation of 16 %.

Tyre tests. — The tyre shall be set up vertically under the gantry and a depression shall be formed, in the center of the tread by the tup, which must be calculated by the formula $E = \frac{D}{100} - \frac{d - 65}{10}$

In this formula E is the depression in % of the internal diameter, D is the tread circle diameter in millimetres, and *d* the average thickness of the tread in millimetres. The tyre must not break or show any defects under this test. The force of a blow when using a tup weighing from 500 to 1 000 kgr. (1 100 to 2 200 lb.) should be 3 000 Kg.-M. (21 700 ft-lb.) and must be increased by 500 Kg.-M. (3 616 ft.-lb.) at each blow if the depression produced by each blow is less than 10 mm. (13/32 inch). The last blow may be varied to obtain the desired depression.

Rails must be rolled from defect-free and solid ingots which have been freed from all impurities and chips. Their tensile strength must be at least 65 kgr./mm² (41.3 Engl. t. per in.²) and the quality coefficient must be at least 900. The quality coefficient is the product of the tensile strength in kgr. and the elongation in % on a length of 200 mm. (7 7/8 inches).

2. Wheel and rail shall work in such a way that both are worn as little as possible. Satisfactory results have so far not been obtained.

3. No.

4. Up to 25 mm. (1 inch).

5. No.

6. This question is not answered.

7. White metal consisting of 80 % tin, 12 % antimony and 8 % copper.

8. In order to combat the bad influence of scale, soda is added to the feed water.

9. *a*) Superheater oil, which is delivered to the cylinders by pressure lubricators of Friedmann make.

b) Machine oil. The rod bearings are fitted with pin trimmings.

10. The cylinders are as a rule, oiled mechanically. Tests are in progress with mechanical oiling for the axles.

11. Reduction of attention.

12. Only when heavy flange wear calls for it.

13. Occasionally on bad sections.

14. Flange greasing reduces the liability to engine derailments.

German State Railways.

V. *Operation.*

1. Engines are double or treble manned.

2. The double set of men system.

3. Mainly in shunting service and in suburban service.

4. Multiple manning system makes for the greatest possible utilization of the engine. In the case of treble manning the costs for personel increase in comparison to the mileage output, the locomotive costs on the other hand decrease,

the upkeep of the engines does not suffer.

5. The largest mileage run by engines in one turn of service is :

a) in express service, about 550 km. (342 miles);

b) in passenger service, about 290 km. (180 miles);

c) running on through goods trains, about 260 km (162 miles).

6. The limits are set by the design of the engine, the length of the section and the timetable.

7. The present rules of service do not impose any limit where multiple crews are used.

8. Coal which clinkers badly reduces the mileage output on a single turn of service. Generous grate dimensions operate in favour of mileage output, while the capacity of the ashpan does not affect matters. Only the pulverised coal engines are mechanically fired.

9. The locomotive boiler as a rule evaporates from 35 to 45 kgr. of water per m² (7.2 to 9.2 lb. per sq. foot) of heating surface per hour, while the consumption of coal per m² per hour is from 270 to 370 kgr. (55.3 to 75.7 lb. per sq. foot). These figures increase to a maximum of 60 kgr. (12.3 lb..) water and 500 kgr. (102 lb.) of coal.

10. The mileage between two heavy repairs amounts to :

	Average. km.	miles.	Maximum km.	miles.
In express service	175 000	(108 700)	350 000	(217 500)
In passenger service	150 000	(93 200)	230 000	(142 900)
In goods service	100 000	(62 100)	160 000	(99 400)

11. In this matter one must differentiate between turning round after a small mileage, as is usual in suburban and local service, and turning round after a higher mileage as is the case in long-distance traffic. In the first instance 10 to 25 minutes is sufficient. In the second case, on the other hand, where the engine fire must be cleaned, the engine must be coaled and again prepared, 2 to 3 hours are necessary.

12. The engines are for the most part equipped with drop grater and ashpan bottom doors.

13. The engines are double and treble manned. They run through as long distances as possible without engine change, the men being changed when necessary at one of the stopping stations. In the case of goods trains, by the provision of small engines at stations to attach and take off wagons.

These measures have raised the daily output by very appreciable amounts No disadvantages are as yet apparent.

14. Yes, a locomotive output premium.

15. Only locomotive staff receive these premiums no matter what grade they belong to.

16. A well cleaned engine permits of breakages, leaks and other incipient defects being easily discovered. Trouble and accidents are thereby avoided and costs eventually reduced. A high value should therefore be placed on a good state of engine cleanliness.

17. Yes, the staff will take greater care of a well cleaned engine. Zeal in service will be increased and work made easier.

Madrid, Saragossa and Alicante Railway Company.

V. *Operation.*

1-3. Train engines are single manned, in a few instances also double. Shunting engines are generally treble manned.

4. Double and treble manned engines use more coal and oil than the single manned engines. No bad results have been noticed in regard to upkeep.

5. Outputs as high as 400 km. (249 miles).

6 and 7. The maximum output during one uninterrupted turn of service is fixed by the legal eight-hour day for the staff.

8. Coal, dimensions of the grate and capacity of the ashpan have no effect, as they permit a larger output than can be obtained under the conditions mentioned in 6 and 7. Mechanical stoking is not in use.

9. At maximum output 60 kgr. of water is evaporated per m² (12.3 lb. per sq. foot) of heating surface and 500 kgr. of coal is burnt per m² (102 lb. per sq. foot) of grate per hour.

The regular average consumption is about 40 % of these figures.

10. As the maximum output under section I, 120 000 km. (74 500 miles) may be taken, no average figure is mentioned.

11. Question II has been misunderstood. It has been answered that on mechanically operated turntables, an engine is turned in 1 minute, while on a hand operated turntable it takes 5 minutes, if it is necessary to remove the tender, 15 to 20 minutes are required.

In most cases, turning has been understood as the operation of turning the engine through 180° instead of the time taken at a terminal station, from the time of arrival with one train until the departure with a train in the opposite direction.

12. Rocking grates are on trial.

13. No.

14 and 15. Drivers and firemen receive fixed premiums for mileage ; special premiums for high mileage do not exist.

16 to 18. These questions have not been answered.

North of Spain Railway Company.

V. *Operation.*

1. Engines are single, double and treble manned.

2. Normally engines are single manned, only in exceptional circumstances are they double manned, owing to shortage of engines and on account of special trains.

3. On shunting work.

4. No experience has been obtained of double manning in train service.

5. About 260 km. (162 miles).

6. The daily work of an engine with a single set of men is limited by the legal 8-hour day ; the work done therefore depends on the personnel.

7. The 8-hour day of the personnel fixes the work done.

8. The question is not answered.

9. At maximum output 400 kgr. of coal per hour are burnt per m² (82 lb. per sq. foot) of grate surface. An evaporation of 7 to 1 is estimated for. The output per m² of heating is not given.

10. From the answer to question number 4 of section I, it may be gathered that all engines receive a heavy repair after about one year.

Output : Express and passenger engines 55 000 to 90 000 km. (34 180 to 55 900 miles). Goods engines, average 36 000 km. (22 370 miles).

11. Turning time depends on the time taken on the turntable.

12. Special measures are unnecessary, as only good coal is used.

13. No.

14. No.

16. A good state of cleanliness of the engines exercices a good influence on

the service; it is not possible to estimate its value.

17. The staff prefers to handle a clean, rather than a dirty engine.

18. Yes.

Portuguese Railway Company.

V. *Operation.*

1. Single manned on long distance traffic, double on local traffic, treble on shunting service.

2. Single manning.

3. In shunting service.

4. The economical results, which should have been achieved by double manning, have not been obtained. Single manned engines are better cared for.

5. 680 km. (422 miles) are given as the highest mileage run between departure from the home station and the return to it. From the answer to question 6 however it appears that there is an intermediate break and that the uninterrupted duty turn is only 340 km. (211 miles).

6 and 7. The mileage run by an engine, on one uninterrupted turn of duty, is governed by the rules as to duration of duty by the engine staff.

8. This question is not answered.

9. 300 to 400 kgr. of fuel per m² (61.4 to 82 lb. per sq. foot) of grate and per hour. The loading of the heating surface is not stated.

10. The highest mileage between two heavy repairs is as follows:

Express engines 90 000 to 100 000 km. (55 925) to 62 100 miles);

Goods engines 50 000 to 60 000 km. (31 050 to 37 300 miles), averages are not given.

11. 2 minutes are mentioned as the shortest time.

12. No.

13. Double manning has been introduced on local service for that reason.

14. No.

16. As premiums are paid for cleanliness, it is evidently considered that cleanliness is highly valued.

17. Yes.

18. It is accepted that the locomotive staff treats a well cleaned engine better and also keeps it up better.

Beira-Alta Railway Company.

1 to 4. Engines are single manned.

5. 252 km. (157 miles).

6. The limits of the engine runs are fixed by the length of the sections.

7. The question of the personnel does not influence the matter.

8. Question 8 has not been answered.

9. From about 200 to 250 kgr. of coal is burnt per hour per m² (41 to 51.2 lb. per sq. foot) of grate surface. The loading of the heating surface is not given.

10. Maximum 120 000 to 140 000 km. (74 600 to 87 000 miles); the average is not quoted.

11. About 11 minutes with hand-operated turntables.

12. A series of engines are fitted with shaking grates.

13. No.

14. No.

16. It is accepted that a clean engine has a good influence on the staff.

17. Yes.

18. Yes.

Netherlands Railways.

V. *Operation.*

1. Single, double- and treble-manned.

2. There is a preponderance of multiple manning.

3. Treble manning is employed when the engine is in use for the whole 24

hours and this condition is repeated daily.

4. Multiple manning results in more economical utilization of the engine.

5. Outputs up to 230 km. (143 miles).

6. Engines must return each day to their home sheds. This determines the limits of the engine run.

7. The working-hour regulations must be taken into consideration in regard to the day's output. Resting of the enginemen and the engine away from the home station is avoided.

8. The factors mentioned in question 8 have no influence on the length of the engines runs.

9. Consumption per hour and per m² of grate area is 450 kgr. (92 lb. per sq. foot); evaporation of water per m² of heating surface per hour is 60 kgr. (12.3 lb. per sq. foot). It is not stated whether this is the maximum or the average, presumably it is the maximum.

10. Passenger train mileage 80 000 to 90 000 km. (49 700 to 55 900 miles). Goods locomotives: 60 000 to 80 000 km. (37 300 to 49 700 miles).

11. The answer reads: « That depends on the distance of the turntable from the main lines. » Times are not mentioned.

12. No, bad coal is not used.

13. No.

14. No.

16. The question is not answered. It is merely stated that great importance is attached to cleanliness.

17. Yes.

18. Yes.

Dutch Indies State Railways.

V. *Operation.*

1. The engines are single manned ; on the largest engines, two firemen are employed.

2-4. Multiple manning is not practised.

5. 371 km. (230.5 miles).

6-7. The length of run is limited by the coal capacity of the tender and by the working-hour regulations for the staff.

8. Coal, grate and ashpan do not affect the limit of output.

If wood is used as fuel the mileage will be less. Mechanical stoking is not in use.

9. This question is answered as « unknown ».

10. The average mileages are as follows for engines with driving and coupled axles :

Of 1 500 mm. (4 ft. 11 in.) diameter, 120 000 km. (74 600 miles);

Of 1 350 mm. (4 ft. 5 5/32 in.) diameter, 100 000 km. (62 100 miles);

Of 1 100 mm. (3 ft. 7 5/16 in.) and below, 85 000 km. (52 800 miles).

11. 2 to 3 hours.

12. No.

13. The daily mileage is kept as high as possible. No special measures are however taken to that end.

14. No. A special mileage premium is paid as compensation for an oil premium which was discontinued.

16. No answer given.

17. It may be taken that the engines are kept as clean as possible.

18. Is not answered.

Swedish State Railways.

V. *Operation.*

1-4. The engine duty sheet is not linked with the sets of men, because it is desired to obtain the maximum use out of the engines.

5. 320 km. (198 miles) for express

trains, 498 km. (309 miles) for goods trains (with stops for fire cleaning).

6. There are no fixed rules for this.

7. The duty sheets for the enginemen are so arranged as to obtain considerable service from the engines.

8. The best coal is used for long runs. Mechanical stoking is not in use; the grate area and ashpan do not influence the maximum mileage.

9. Maximum output 500 kgr. per m² (102 lb. per sq. foot) of coal and 65 kgr. per m² (13.3 lb. per sq. foot) water evaporated per hour.

10. The mileage between two heavy repairs varies between 120 000 and 200 000 km. ((74 600 and 124 200 miles).

11. The turning times vary with local conditions; figures are not given.

12. No.

13. No.

14. No.

16. No experimental results.

17 and 18). These questions have not been answered.

Danish State Railways.

V. *Operation.*

1 to 3. — It may be concluded from the answers to questions 1 to 3 that engines are single manned, the shunting engines (yard engines) with one man only.

4. Question 4 is not answered.

5. 120 to 130 km. (74.6 to 81 miles).

6. The length of the engine run is fixed by the length of the section.

7. The length of the engine run does not depend upon the enginemen. If necessary the men are changed at intermediate stations.

8. Coal, the size of the grate and the ashpan do not influence the mileage limits. Mechanical stoking is not in use.

9. Maximum 300 to 400 kgr. per m² of grate (61.4 to 82 lb. per sq. foot) of coal, and up to 70 kgr. per m² of heating surface (14.3 lb. per sq. foot) of water evaporated per hour.

The usual loadings are not mentioned.

10. Mileage between two heavy repairs is:

Passenger engines:

Average : 100 000 km. (62 100 miles).
Maximum: 165 000 km. (102 500 miles).

Goods engines:

Average : 70 000 km. (43 500 miles).
Maximum: 133 000 km. (82 600 miles).

11. 1 1/2 to 2 minutes where the tables are mechanically operated and 5 minutes by hand.

12. No.

13. Double crewing has been introduced for that reason.

14. No.

16. A good condition of cleanliness increases the interest of the personnel.

17. Yes.

18. The question is not answered.

Norwegian State Railways.

V. *Operation.*

1 to 4. In answer to these questions it is stated that the smallest shunting engines are operated by one man.

5. 228 km. (142 miles).

6 to 8. The length of an engine's runs is in part governed by the class of train, in part by the gradients on the section and in part by the size of the grate.

9. Maximum coal consumption 450 kgr. per m² (92 lb. per sq. foot of grate area) and 60 kgr. per m² (12.3 lb. per sq. foot of heating surface) water evaporated. The usual loading is not given.

10. The mileage run between two heavy repairs is :

Express engines :

Average : —

Maximum: 200 000 km. (124 000 miles).

Passenger engines :

Average : 90 000 km. (55 900 miles).
Maximum : 120 000 km. (74 600 miles).

Goods engines :

Average : 80 000 km. (49 700 miles).
Maximum : —

11. Depends on the turntable.

12. No.

13. In order to raise their mileage, the engines of certain trains are run beyond the frontier. Enginemen and engines are changed at convenient points.

14. No.

16. A good state of cleanliness raises the interest of the staff.

17. Yes.

18. Is not answered.

Finnish State Railways.

V. *Operation.*

1. Double-, partly treble-manned.

2. The double manning system.

3. Shunting engines are partly treble-manned.

4. Upkeep of the engines, care of the tools and spare parts, are unsatisfactory. Increased cost of upkeep of the engine, especially of the boiler.

5. 273 km. (170 miles).

6. The answer reads : « No limits set ». The question is wrongly interpreted.

7. This is answered, that the maximum working time of the engine staff is 16 hours.

8. Coal, size of grate and capacity of ashpan do not limit mileage on an uninterrupted turn of duty.

9. Coal consumption as a rule 300 kgr. per m² (61.4 lb. per sq. foot) of grate per hour and water evaporated, about 32 kgr. per m² (6.6 lb. per sq. foot) of heating surface (superheater included).

10. The mileage run between two heavy repairs is :

Express and passenger :

Average : 85 000 km. (52 800 miles).

Maximum : 160 000 km. (99 400 miles).

Goods :

Average : 60 000 km. (37 300 miles).
Maximum : 130 000 km. (80 780 miles).

11. About from 30 to 40 minutes.

12. No.

13. Running longer lengths, changing the men, double-manning and quick turn round of the engines to their starting points.

14. A coal premium is paid and in addition, an axle premium on goods trains.

15. Driver and fireman.

16. Good cleaning permits small defects to be seen and these can be remedied at small cost. As a result heavy damage and heavy expense are avoided.

17. Yes.

18. It is probable that a small increase in the cost of cleaning of engines may be compensated for by an increase in the mileage run.

Swiss Federal Railways.

V. *Operation.*

1. Engines are double-, treble- manned and not allotted to given sets of men.

2. Multiple, and since some time, pooled.

3. In electric operation on the St. Gothard line.

4. Multiple manning secures the best utilization of the engine. No noticeable disadvantage reported.

5. The mileage of the electric express engines is 990 km. (615 miles) and that of the goods engines, 630 km. (391 miles) per day.

6. These mileages depend on the timetable.

7. The personnel question does not affect the mileage, where multiple manning (pooling) is done.

8-9. These questions are not answered.

10. Is not answered.

11. This depends on the turntable drive. Average 5 minutes.

12. The larger engines have rocking grates.

13. The question is not answered in regard to steam locomotives.

14. No.

15. —

16. Good cleaning eases the work of upkeep and makes it possible to detect damage. In this sense, good cleaning tends to increase safety in working.

17. Yes, the engine staff attend to, and examine a well cleaned engine, better than a badly cleaned one.

18. The question is not answered.

German State Railways.

VI. *General.*

1. During the last 10 years no basic alterations have been made in locomotive design.

The heavy express engines which were in service up to 1918, had a grate area of 3.18 m² (42 sq. feet) and heating surface of 161 m² (1 733 sq. feet) (not including superheater surface). At the present day the largest express engines have a grate area of 4.5 m² (48.4 sq. feet) and 247 m² (2 659 sq. feet) of heating surface. Train weights and speeds (train resistances) have not increased in an equal ratio; the loading of the grate and heating surface per m² has also decreased, not only in the case of the express engine, but generally for all engines. Much more powerful engines are employed today for the same loads as were hauled formerly. This has worked out satisfactorily in spite of the somewhat higher capital charges and has helped towards the high mileage.

The mud separator already mentioned in section IV, should here be again referred to, seeing that it has now only become a standard locomotive accessory.

The engine maintenance in the railway repair works and the good and systematic attention given in the running shed repair works and by the enginemen has been still further improved during the last 10 years. In this respect perhaps the best has been achieved.

In order to increase the life of the axlebox bearings, all the new and old heavy goods engines have been fitted with the Obergethmann bearing. This bearing consists of the normal crown brass and 2 auxiliary side bearings which are held up against the crown brass by the pressure of the axlebox keep : These parts can be adjusted to take up wear by means of adjusting screws in the horn plate clips : they can take up a proportion of the large horizontal thrust and relieve the coupled axle and rod brasses.

In late years further attempts have been made to increase the mileage run by main line engines by using several sets of men, when the sections run over are not too long. It is however probable that this attempt will not be extended very much further. If an engine works a length from A to B, starting from A and if the men go off duty at B, then the engine can be used to work a train from

B to C and back while the men are resting, but care must be taken to see that the staff working is properly planned and that the men from B are always linked with the same set from A. An immediate increase in the engine mileage may well be obtained, but it is at least doubtful if coal consumption and maintenance costs will remain at the corresponding level. Again if the mileage of certain engine links is increased, other may suffer and action should therefore be confined to suitable cases.

2. The good fit of the axlebox brasses in the axlebox is of special importance, if long life is to be obtained. Brasses are therefore fitted in the axleboxes with the greatest care. The process is approximately as follows: The axlebox is gauged and when doing so it is necessary that care should be taken to see that the inside faces are machined square with the face of the crown. The centre line of the axlebox is accurately marked, the centre of the brass and its outside dimensions are fixed, and the brass is then machined. The brass is then fitted in the box and the control circle is marked. The axlebox and brass are then set up on a boring machine and the brass is accurately bored out to the journal dimensions. The brass is then removed from the box and the white metal is run in. If, during this process the diameter of the brass becomes smaller, it is re-set under a screw press, using a mandrel for the purpose, and is again fitted into the box. When the oil grooves have been cut, the brass is finish-bored and fitted to the journal by scraping.

The following is the method prescribed for driving and coupling rods: Oil boxes and bearings are removed and the rods are thoroughly cleaned so that they can be examined for cracks. Bearing centre lines are checked, marked, or corrected. The outside faces are then checked for parallelism. The faces on which the brasses bear are checked and if required are trued up. The knuckle pin holes are checked and the centre lines are punch marked.

Driving- and coupling rod bearings are to be treated as follows: The thrust faces of the brasses are machined (sufficient thickness of metal must be left for boring). The centre line is marked vertical with the thrust face. All faces must be square with one-another and the cotter face must be at the correct angle. Worn areas on the faces or the thrust faces of old brasses must be welded up with brass wire: metalling up with white metal is prohibited. All faces of the brass must bear, but the corners must be clear. All screw cotters must be properly fitted with a side clearance of from 3 to 5 mm. (1/8 to 13/64 inch). The brasses are then assembled in the rods and bored out to the size of the pin (plus 1 mm. 3/64 inch). The control circle for metalling is then marked. The bearings are removed from the rods and are filled with white metal in accordance with the control circle and the size of the pins. The total side play on the pins must be 1.5 mm. (0.059 inch) and this shall agree with the side play in axleboxes. Where axles have play, clearance equivalent to the side play of the axle must be given. The bearing surfaces of the brass itself must have the white metal backed off so that an oil film can form. The brasses are then fitted with adjusting liners 4 mm. (5/32 inch) thick, the cotter blocks are inserted and the brasses are then bored out. The liners must not come in contact with the pin. The brass must be bored from 0.1 to 0.2 mm. (0.0039 to 0.0078 inch) larger than the pin. Oil boxes are fitted. In summer the oil flats are kept smaller and the needles thicker than in winter.

Driving- and coupling rod brasses call for very little upkeep during service. If they thrust out, the 4-mm. liners are replaced by weaker ones.

3. Driving- and coupled axles are dealt with as follows:

Whenever work necessitates the remo-

val of the driving- and coupled axles, they must be examined. Each axle is to be examined, in a good light, throughout its entire length and circumference, in the radii of journals and driving pins as well as in the key seats, for damage and defects. The diameters of the journals and the crank pins must be ascertained and in the case of crank axles a form must be filled up and attached to the service register. If a crack is suspected in or close to the hub of the wheel, the wheel must be pressed off for one third of its thickness. The wheels are then run over 5-cm. (2-inch) thick wood packings placed on the rails. The jar sustained in this process, forces the oil out of any cracks existing. If the axle is sound it is pressed back and the journals are turned or ground. The highest permissible deviation of the journals from the circle is 0.3 mm. (0.0118 inch). No deviation is permitted for newly-ground or new axles. If any defect is found in a double crank axle, the works' manager, that is to say the senior official of the works, will decide as to the further use of the axle. Should the axle not be scrapped, a sketch must be attached to the report, showing the nature and dimensions of the defect. If the defect should be of a serious nature or if on account of previous knowledge, special control should be desirable then the axle must be examined after a fixed mileage. Such axles are specially marked.

If a defect should be detected or suspected in a driving- or coupled axle, in a running shed repair works, the engine concerned must be sent to a main repair works for examination.

4. Has already been answered (see 2).

Madrid, Saragossa and Alicante Railway Company.

VI. *General.*

1. Improved arrangement of the plates and longer stays have permitted the free expansion of the firebox and lengthened its life, hence increased mileage.

2. Axlebox- and rod brasses are treated with emery on the faces to which white metal must adhere, the bearings are turned and ground.

3. At each heavy repair the journals of the axles are turned and ground and in some instances burnished and hardened by rolling.

The same operations are carried out if a bearing runs hot.

4. See 2) and 3).

North of Spain Railway Company.

VI. *General.*

1-2. Questions 1 and 2 are not answered.

3. Axle journals are ground in special emery grinding machines.

4. Brasses are filled with white metal.

Portuguese Railway Company.

VI. *General.*

1. It is taken that regular examinations and repairs, carried out after a fixed mileage, tend to increase the mileage run.

2. Bearings and journals are ground.

3-4. These questions are not answered.

Beira-Alta Railway Company.

VI. *General.*

1. By way of a trial, a few engines have been fitted with hot water pumps (feed water heaters) which condense the exhaust steam.

2. Axlebox-bearings are not specially treated while in service. Recently, rod bearings have been filled with white metal, where it has been found necessary. When heavy repairs are carried out, it is the general practice to fill axlebox- and rod bearings with white metal.

3. When carrying out heavy repairs

the axle journals are got up by hand when they have cut.

4. The old anti-friction metal is first run out of the bearings, these are then re-filled with new metal, fitted on the journals and again put in place.

Netherlands Railways.

VI. *General.*

1. The driving axles of some engines have been fitted with axleboxes with side bearings.

2. When heavy repairs are carried out, the bearings are filled with fresh white metal.

3. When heavy repairs are carried out, the driving- and coupled axle journals are ground up if they are more than 0.3 mm. (0.0118 inch) out of round.

4. In the usual way, at the time of the general repairs.

Dutch Indies State Railways.

VI. *General.*

1. Every effort is made to carry out heavy repairs in the minimum of time.

2. At each heavy repair, the axlebox- and rod brasses are re-filled with new white metal and they are then refitted to the pins and journals.

3. The axle journals of the driving- and coupled axles are gone over at each heavy repair and if they are found to be out of round they are re-ground.

4. See answer to question 2.

Swedish State Railways.

VI. *General.*

1. No constructional alterations have been recently made which have led to appreciable increase in the mileage output.

It appears that the mileage run is considerably increased if tyres are returned at one of the periodical examinations.

2. The axlebox- and rod bearings are gauged at the examinations, and at least once more between two following examinations. If the removal of the liners from the rod bearings is not enough, the bearing metal is removed and replaced. Large bearings are fitted by hand, while small ones are machined.

3. The axle journals of the driving- and coupled axles are only gauged at heavy repairs. If necessary they are trued up by grinding.

4. Filling and finishing of bearings is carried out in the usual way. When running in the driving pin bearings of the electric locomotives, the bearings are bolted on a lathe and warmed up. The white metal is poured while the bearing is rotated at a high rate of speed. While cooling under centrifugal force, the metal takes on a very hard and wear-resisting face.

Danish State Railways.

VI. *General.*

1. The careful maintenance of the oiling arrangements and the increased strength of the rails have assisted toward the increased mileage output between two repairs.

2-4. Axlebox- and rod bearings are gauged. Double cranked axles are examined after 75 000 km. (46 600 miles) and single crank axles after 100 000 km. (62 100 miles). The journals of the driving and coupled axles are ground when heavy repairs are carried out. They are only filed up in the running shed repair works. As a general rule bearings are white metalled in the main shops only.

Norwegian State Railways.

VI. *General.*

1. No.

2. The question is not answered.

3. There is no periodical examination of axle journals for circularity.

4. The bearing brasses are filled by hand. In order to utilize centrifugal force to obtain sound casting, the bearings are rotated at high speed when being filled. Rod bearings are as a rule bored out after they have been fitted in the rods and they are then fitted to the pins by hand scraping.

Finnish State Railways.

VI. *General.*

1. More copper fireboxes are used than formerly.

2. Is not answered.

3. The journals of driving- and coupled axles are gauged at each repair and are re-ground if necessary.

4. The white metal is cast into the bearings, which are then fitted in the rods and they are then bored out in position on a vertical boring machine. They are fitted to the pins by hand.

Swiss Federal Railways.

VI. *General.*

1. The following measures have assisted to raise the mileage between two heavy repairs : Equal distribution of the axle loads. All-round improvements in construction, especially in the matter of lubricating arrangements, as well as the use of high class material. Specialization of the shops for the maintenance of rail motor vehicles.

Special attention is paid to the details most highly stressed.

2) Lubrication of bearings is most carefully attended to and incipient play in the bearings and axleboxes is put right as soon as possible.

The crank pins of driving- and coupled wheels are carefully gauged at each examination and if the wear amounts to 0.5 mm. (0.0197 inch) or over they are turned up or ground.

4) Bearings are refilled at each examination and new metal is used in the case of the more highly stressed bearings. In the case of the less highly stressed bearings, metal remade from old metal is used. The bearing brasses are carefully tinned before filling so that the best possible connection may be obtained between the shell and the bearing metal. After the newly filled bearings have been carefully machined, they are fitted to the journals by filing and scraping.

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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

XIIth SESSION (CAIRO, 1933).

QUESTION III:

The relationship between the vehicle and the track, to ensure safety at high speeds:

A. Weight of vehicles per axle, position of the centre of gravity, wheel arrangement, layou to facilitate running through curves.

B. Track resistance, widening of gauge, radius of curves, superelevation, transition curves, points and crossings, check rails.

REPORT No. 1

(America, Great Britain, Dominions and Colonies, China and Japan),

by Dr. S. MATSUNAWA,

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Chief of the Rolling Stock Section, Japanese Government Railways.

According to the requirements of Question III, Section I, for the Cairo Session of the International Railway Congress Association, the discussion is to be made on the relation between the railway vehicle and the track from the view-points of the vehicle and the track respectively, for ensuring the safety of the trains running at high speeds.

As, however, Section I of the Congress deals generally with way and works, we put questions to the railways of the specified countries chiefly about those points which were regarded to be related more closely with the track, though questions of a more technical nature about the vehicle might as well have been of interest.

In this connection we asked the railway administrations to bear in mind that, by the nature of this subject, the following questions were related to more important railway lines under high speed train working and to the principal vehicles running over them.

A. — Weight of vehicles per axle, position of the centre of gravity, wheel arrangement, layout to facilitate running through curves.

Question 1. — *Please inform us of the classes of locomotive (including steam, electric and other special locomotives) now regarded as of standard type for high-speed train working and the diameter and arrangement of wheels, axle load, height of the centre of gravity, arrangement and number of steam cylinders (systems of motor suspension and*

TABLE I.

RAILWAYS. / Item.	Japanese Government Railways.	Delaware and Hudson Railroad.	Federated Malay States Railways.	Baltimore and Ohio Railroad.	South Indian Railway.	Norfolk and Western Railway.
Gauge . . . mm.	1 067	1 435	1 000	1 435	1 676	1 435
Arrangement of wheels . . .	4-6-2	4-6-2	4-6-2	4-6-2	4-6-2	4-4-2
Diam. of driving wheels . . . mm.	1 750	1 854	1 372	2 032	1 880	2 006
Diam. of leading wheels . . . mm.	860	838	762	914	914	914
Diam. of trailing wheels . . . mm.	860	1 143	851	1 320	1 092	1 270
Diam. of tender wheels . . . mm.	860	838	851	914	1 092	838
Maximum axle load . . . t.	15.44	30.77	16.26	30.85	17.27	19.82
Weight of locomotive in working order, including tender . . . t.	129.98	225.18	111.30	246.82	157.55	152.19
Number and arrangement of steam cylinders.	Outside 2, inside 1.	Outside 2.	Outside 2, inside 1.	Outside 2.	Outside 2.	Outside
Height of center of gravity . . mm.	1 587	1 829	1 524	1 943	1 778	...
Maximum speed . . . km/h.	100	120.8	64	129	96.6	127

RAILWAYS. / Item.	New South Wales Government Railways.	Railways of China.	Sudan Government Railways.	New York Central Lines.	Canadian National Railways.	Buenos Ayres and Pacific Railway.
Gauge . . . mm.	1 435	1 435	1 067	1 435	1 435	1 676
Arrangement of wheels . . .	4-6-0	4-6-2	2-6-2	4-6-4	4-6-4	4-6-2
Diam. of driving wheels . . . mm.	1 753	1 753	1 588	2 007	2 032	2 045
Diam. of leading wheels . . . mm.	991	...	914	914	870	940
Diam. of trailing wheels . . . mm.	...	...	914	No. 1: 914 No. 2: 1 295	No. 1: 870 No. 2: 1 219	940
Diam. of tender wheels . . . mm.	940	...	851	914	870	1 067
Maximum axle load . . . t.	20.47	17.00	16.26	25.02	28.53	19.36
Weight of locomotive in working order, including tender.	161.60	...	129.30	274.18	300.39	151.96
Number and arrangement of steam cylinders.	Outside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2.	Outside
Height of center of gravity . . mm.	1 626	1 981	...	1 924	1 924	1 985
Maximum speed . . . km/h.	96.6	64.4	...	127.2	120	105

am locomotives.

Reading Company.	Canadian Pacific Railway.	Government Railways of Chosen.	New Zealand Government Railways.	Cordoba Central Railway.	British Railways (Railway Clearing House).	Central of Georgia Railway.	Madras and Southern Mahratta Railway.	South African Railways and Harbours.
1 435	1 435	1 435	1 067	1 000	1 435	1 435	1 435	1 067
4-6-2	4-6-4	4-6-2	4-6-2	4-6-2	4-6-0	4-6-2	4-8-2	4-6-2
2 032	1 905	1 750	1 372	1 372	2 057	1 753	1 880	1 524
914	838	860	775	...	1 003	838	876	762
1 372	No. 1: 921 No. 2: 1 143	1 020	673	...	...	1 219	1 092	864
914	921	864	775	...	1 295	838	914	864
29.42	27.86	18.50	10.49	13.92	21.23	30.09	17.32	19.00
21.39	292.36	147.5	86.11	...	129.64	278.33	148.54	159.06
tside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2. inside 1.	Outside 2.	Outside 2.	Outside 2.
1 964	1 880—1 981	1 650	1 359	...	1 791	1 829	1 981	...
136.8	160.9	95	80.5	70	...	112.7	96.6	88.6

Nigerian Railway.	North Western Railway (India).		Burma Railways.	South Manchuria Railway.	Pennsylvania Railroad.	Illinois Central System.	Richmond Fredericksburg & Potomac Railroad.	Wabash Railway.
1 067	1 676	1 000	1 000	1 435	1 435	1 435	1 435	1 435
4-6-2	4-6-2	4-6-2	4-6-2	4-6-2	4-6-2	4-6-2	4-6-2	4-6-2
1 524	1 880	1 448	1 448	1 850	2 030	1 900	1 910	1 880
838	914	724	724	840	915	870	915	838
838	1 092	762	762	1 120	1 270	1 220	1 220	1 124
838	1 092	724	724	840	...	914	914	914
12.74	21.84	10.07	12.2	22.55	33.0	25.7	30.5	24.37
98.29	174.91	86.22	93.03	171.17	151.0 Exclusive of tender.	210.0	238	187.45
tside 2.	Outside 2, inside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2.	Outside 2.
...	...	...	...	1 850	2 030	...	1 980	...
64	128.8	80.5	64	95	129	...	143	120

TABLE 2. — Electric locomotives.

RAILWAYS. / Item.	Japanese Government Railways.	Baltimore and Ohio Railroad.	British Railways (Ry. Cl. House).	South African Railways and Harbours.	New York Central Lines.	Pennsylvania Railroad.
Gauge . . . . mm.	1 067	1 435	1 435	1 067	1 435	1 435
Arrangement of wheels . . .	2-C-C-2	B-B	2-C-2	B-B	B-B-B-B	2-C-2
Diam. of driving wheels . mm.	1 250	1 270	2 032	1 219	914	1 830
Diam. of leading and trailing wheels . . . . mm.	860	...	1 099	...	...	915
Maximum axle load . . . t.	13.4	27.22	19.9	17.03	16.16	33.2
Weight of locomotive in working order . . . . t.	108	108.88	110.05	811	129.27	152
Number of motors	6	4	3	4	8	6
Horse power of one motor . .	306	...	304	304	...	...
Power transmission of motors.	Nose suspension system. Single reduction.	Nose suspension system. Single reduction.	Quill system. Single reduction.	Nose suspension system. Single reduction.	Field frame built into truck unit.	Flexible gear.
Height of center of gravity . . . . mm.	1 205	...	1 473	1 245	1 207	1 780
Maximum speed . . . km/h.	105	63	82.9	72.5	120.8	145

power transmission of electric locomotives) and maximum speed of these locomotives, according to the appended forms.

The answers to this question are summarized in table 1 (for steam locomotives) and table 2 (for electric locomotives).

As shown in table 1, the steam locomotives used for high-speed train working are, with a few exceptions, of the *Pacific* type.

The diameter of driving wheels ranges from 1 750 to 2 057 mm. (5 ft. 8 1/4 in. to 6 ft. 9 in.) for tracks of the standard and broad gauges (1 435 mm. = 4 ft. 8 1/2 in. and over), and the largest diameter for the narrow gauge (1 067 mm. [3 ft. 6 in.] and downwards) is 1 750 mm. (5 ft. 8 1/4 in.) on the Japanese Government Railways.

The maximum axle load varies according to the size or the weight of locomotives and also to the cross-section of the rail. It ranges from 17 to 33.0 tons for tracks 1 435 mm. and over in gauge, and from 10 to 16.26 tons for the narrow gauge.

The weight of locomotives in working order varies from 147.5 to 300.39 tons for the standard and broad gauges and from 86.11 to 159.06 tons for the narrow gauge.

As to cylinder arrangement, inside steam cylinders, in spite of their good running quality for high-speed train working, are adopted by only a few railways. Three-cylinder locomotives are, however, in service on the Japanese Government Railways, Federated Malay States Railways and some British railways (members of the Railway Clearing House), and 4-cylinder locomotives on the North Western Railway (India). Locomotives with 2 outside cylinders are run on other railways.

As to the height of the centre of gravity of the locomotives above the rail surface, it is 1 359 to 1 587 mm. (4 ft. 5 1/2 in. to 5 ft. 2 15/32 in.) for the narrow gauge track, while the largest one for the standard and broad gauge comes up to 2 030 mm. (6 ft. 8 in.).

As the centre of gravity gets higher, the running becomes smoother and the impact against the rail decreases. So, the centre of gravity should be made high, so far as the locomotive is free from the danger of overturning.

Let us assume that the ratio of the gauge to the height of the centre of gravity represents the degree of safety against overturning.

The degree of the safety against overturning of the locomotive of the Japanese Government Railways is the minimum, which is 1/149, while the minimum of the standard and broad gauge locomotives is 1/141. This fact indicates that the centre of gravity of locomotives for the standard and broad gauge tracks can be placed higher than at present without causing any difficulty in train working, though there is some difference in the maximum speed of the standard and narrow-gauge locomotives.

The highest speed for the narrow-gauge track is about 100 km. (62 miles) per hour and has been reached by the Japanese Government Railways, while that for the standard gauge track is 160.9 km. (100 miles) per hour, which has been obtained by the Canadian Pacific Railway. But this difference in speed is an extreme case and the difference in daily train service is by far smaller.

Unfortunately, we have been given very few answers as to electric locomotives. The data obtained from the scanty answers are given in table 2, which shows that the reporting railways have little experience of the use of electric locomotives for high-speed train working.

Question 2. — *We want to know your opinion about the following points with respect to the track and bridges in designing a locomotive for high-speed train working :*

I. *Limits to the axle load and wheel base.*

II. *Dynamic effect :*

a) *effect produced by the unbalanced centrifugal force (the answer may be given in x % of the wheel load or in other proper ways).*

b) *effect of the speed (the answer may be expressed in relation between the revolution or diameter of the driving wheels and the speed).*

III. *Comparison between the single-axle truck, the special single axle truck such as the Krauss and Zara and the double-axle bogie. The extent to which these trucks and bogies may be applied with respect to speeds.*

IV. *Height of the centre of gravity :*

a) *maximum height allowed;*

b) *height preferred.*

V. *Arrangement and number of steam cylinders.*

VI. *Designs for minimizing the unsprung weight (Information is also requested about designs for this purpose of goods wagons and passenger carriages).*

VII. *Designs of the construction of electric locomotives for minimizing the unsprung weight.*

VIII. *Amount of the spring deflection and types of spring suspension.*

IX. *Regulations concerning the cross-section of worn wheel flanges, as for instance, those concerning the thickness, angles of the flange surface to the vertical, sharp points, etc.*

TABLE 3.

RAILWAYS.	Gauge.	Limit to axle load (*t.*).	Remarks.
Japanese Government Railways	1 067	A-class lines, 16 tons; in special cases, 18 tons. B-class lines, 15 tons. C-class lines, 13 tons.	Calculation for bridges is made on a system similar to Cooper's. Investigations are being made, as to calculation for track, on a similar system.
Delaware and Hudson Railroad	1 435	31.8	Cooper's E 70 for bridges.
Federated Malay States Railways	1 000	Tons (long) ×1/5 of number of lb. of rail per yard.	
Baltimore and Ohio Railroad	1 435	29.5	
Norfolk and Western Railway	1 435	30.9	
Reading Company	1 435	35.4	
Canadian Pacific Railway	1 435	29.5	
Government Railways of Chosen	1 435	22.0 (A-class lines).	18 tons for B-class lines, and 15 tons for C-class lines.
British Railway (Ry. Cl. H.)	1 435	...	Calculation for bridges is made by a method similar to Cooper's system.
Central of Georgia Railway	1 435	27.3	
Madras and Southern Mahratta Ry.	1 435	17.8	
South African Railways and Harbours.	1 067	18.3	
New South Wales Government Railways.	1 435	...	Cooper's E 50 for bridges.
Kansas City Southern Railway	1 435	* 28 × 34	* For single track section with curves or steep gradients. × For sections free from dynamic effects due to concentration of axle load.
New York Central Lines	1 435	25.02	
Canadian National Railways	1 435	...	Cooper's system for bridges.
Buenos Ayres and Pacific Railway.	1 676	22	For 50 kgr./m. rail and for minimum wheel base of 1 524 mm.
Nigerian Railway	...	12.7	
North Western Railway (India)	1 676 1 000	22.86 13.21	
Burma Railways	1 000	12.17	
South Manchuria Railway	1 435	25.00	Calculation for bridges is made by assuming the axle load as 22 tons and the wheel base as 1.5 m.
Pennsylvania Railroad	1 435	27.2	This is the weight on a journal of driving wheels.
Richmond Fredericksburg and Potomac Railroad.	1 435	31.2	
Wabash Railway	1 435	31.5	Calculation for bridges is made by a method similar to Cooper's system.

X. *Advantages and amount, if any, of the conicity of the wheel tread.*

XI. *Others.*

I. *Limits to the axle load and wheel base.*

By putting this question we intended to obtain data about the wheel spacing with respect to the strength of track or bridges, but the answers for the most part are somewhat beside the point, because they deal with the rigid wheel base with respect to the facility with which locomotives are run through curves.

In the calculation for bridges, Cooper's system or similar ones are adopted by the Japanese Government Railways, the Delaware and Hudson Railroad, the principal British Companies, the New South Wales Government Railways, the Canadian National Railways and the South Manchuria Railway. In the calculation for track, just as for bridges, it may be theoretically right that the axle load and the wheel spacing should at the same time be taken into account. But while a large wheel spacing has a better effect upon the bridge, a small one within certain limits is more desirable for track. Thus, the difficulty is encountered that a locomotive which is desirable for the bridge si not so for the track. As seen from the answers to our question, quite a large number of railways make calculation by taking into account both the axle load and the wheel spacing for the bridges as in Cooper's system, but few seem to do so for the track. In other words, most railways make calculation for track on the basis of the single axle load.

It may, however, be recommended that a method of more accurate calculation for track be used or the effect of adjacent axle loads be taken into account, if the track is to be burdened more heavily, so that its full strength may be utilized.

The above-mentioned answers relative to the axle load limits and to wheel spacing are summarised in table 3.

II. *Dynamic effect :*

a) *Effect produced by the unbalanced centrifugal force. (The answer may be given in x % of the wheel load or in other proper ways.)*

The answers to this question are shown in table 4.

In this table the value of the effect produced by the unbalanced centrifugal force is expressed in x % of the wheel load for the maximum speed, for 5 r. p. s. of the driving wheel or for the diameter

TABLE 4.

RAILWAYS.	*Effect produced by the unbalanced centrifugal force at the velocity V.*	V.
Japanese Government Railways	15 % of wheel load.	Designed max. speed.
Federated Malay States Railways	20 % of wheel load.	5 r. p. s. of driving wheel.
Baltimore and Ohio Railroad	Axle load + hammer blow effect $<$ 31.8 ton.	Diameter speed.
Norfolk and Western Railway	30 % of wheel load.	Max. speed.
Reading Company	50 % of wheel load.	Diameter speed.
Canadian Pacific Railway	75 % of wheel load.	Max. speed.
New Zealand Government Railways	23 % of wheel load.	Max. speed.
Central of Georgia Railway	50 % of wheel load.	Max. speed.
New South Wales Government Railways.	40 % of wheel load.	5 r. p. s. of driving wheel.
Railways of China	25 % of wheel load.	Diameter speed.
New York Central Lines	50 % of wheel load.	Diameter speed.

TABLE 4. (*Continued.*)

Canadian National Railways . . .	43 % of wheel load.	Max. speed.
Buenos Ayres and Pacific Railway .	30 % of wheel load.	Max. speed.
South Manchuria Railway	50 % of wheel load.	Diameter speed.
Pennsylvania Railroad	30 % of wheel load.	5 r. p. s. of driving wheel.
Illinois Central System	38.5 % of wheel load.	Max. speed.
Richmond Fredericksburg and Potomac Railroad.	50 % of wheel load.	Diameter speed.
Wabash Railway	50 % of wheel load.	Diameter speed.

speed (*) of locomotives. The value so far available varies very widely, that is, from 15 % to 75 %. Since eventually the maximum speed, 5 r. p. s. of the driving wheel and the diameter speed (*) of locomotives will give nearly the same value, the difference in the ratio to the wheel load of the effect due to the unbalanced centrifugal force comes only from the difference of practice and has no sufficient reason. But the difference seems to some extent to be affected by track conditions, that is, the gauge and the rail section. The fact that the value expressed in x % for narrow-gauge railways, such as the Japanese Government Railways, the Federated Malay States Railways and the New Zealand Government Railways, is made much smaller than that for standard gauge railways, shows that the smaller ratio is recommended for ensuring safety.

b) *Effect of the speed. (The answer may be expressed in relation between the revolution or diameter of the driving wheel and the speed.)*

The answer to this question may be considered to have been roughly covered by those to the foregoing question *a*).

III. *Comparison between the single axle truck, the special single axle truck such has the Krauss and Zara and the double axle bogie. The extent to which these trucks and bogies may be applied with respect to speeds.*

The answers to this question are summarized in table 5. It will be seen from the table that the double axle bogie is almost exclusively used for high-speed train working, the single axle truck being used for goods traffic alone. The reporting railways seem to have little experience with special single axle trucks, such as the Krauss and Zara.

(*) The diameter speed means « the speed expressed in as many miles per hour as the number of inches representing the diameter of the driving wheel ».

TABLE 5.

RAILWAYS.	*Single-axle trucks and double-axle bogies in use.*
Japanese Government Railways . .	Generally, double-axle bogie. Single-axle truck is used for the maximum speed of less than 85 km./h. Single-axle truck similar to the Krauss is also in use.
Delaware and Hudson Railroad . .	Exclusively double-axle bogie.
Baltimore and Ohio Railroad . . .	Double-axle bogie only is used for passenger locomotives.
Norfolk and Western Railway . . .	Double-axle bogie carries heavier load and has more guiding effect than single-axle truck. No experience with the use of the Krauss and Zara systems.

TABLE 5. (*Continued.*)

Reading Company	Double-axle bogie for high-speed passenger locomotives. Single-axle truck might be so designed as to act in the same way as double-axle bogie, but this railway has no experience with passenger locomotives of such a design.
Canadian Pacific Railway	Single-axle truck is not desirable for high-speed locomotives. Double-axle bogie has better guiding effect on passenger locomotives than the single. Double-axle bogie gives less wear of wheel flanges and can carry heavier load.
Cordoba Central Railway	Most of passenger locomotives have double-axle bogie. Double-axle bogie is better for high-speed locomotives, so far as safety is concerned.
British Railways (Ry. Cl. H.)	Double-axle bogie is generally in use for high-speed locomotives.
Central of Georgia Railway	Same as British Railways.
South African Railways and Harbours.	This railway has no experience with the use of the Krauss for high-speed locomotives. No limits of speed to which single-axle trucks can be used have been fixed as yet.
New South Wales Government Railways.	None but double-axle bogies are used for high-speed locomotives.
Railways of China	Same as New South Wales Government Railways.
Kansas City Southern Railway	Double-axle bogie is adopted for high-speed locomotives. Double-axle bogie is adopted for the trailing truck as well as for the leading truck when there is a fear of large rail stress being produced by the single-axle truck.
New York Central Lines	All the passenger locomotives are equipped with double-axle bogie, as it has larger load capacity and better guiding effect.
Canadian National Railways	Double-axle bogie alone is used for high-speed working. This railway has no experience with such trucks as the Krauss or the Zara. American designers do not regard it as useful.
Buenos Ayres and Pacific Railway	Double-axle bogie is used for high-speed locomotives. This railway has no experience with the Krauss or the Zara.
Nigerian Railway	Same as Buenos Ayres and Pacific Railway.
North Western Railway (India)	Double-axle bogie is used for high speed locomotives, no comparative investigations having been made of this and single-axle bogies.
Burma Railways	Double-axle bogie alone is used for high-speed passenger locomotives.
South Manchuria Railway	Same as Burma Railways.
Pennsylvania Railroad	Either of single and double-axle bogies will do, so far as the designs are good.
Illinois Central System	Double-axle bogie alone is used for high-speed locomotives.
Richmond, Fredericksburg and Potomac Railroad.	Same as Illinois Central System.
Wabash Railway	No experience with the Krauss and Zara types of bogie truck. Only double-axle bogie is used for locomotive for high-speed train working.

As the locomotive for high-speed train service requires several truck axles for bearing its heavy weight, it is quite natural that two truck axles should be combined to make a leading bogie and this has everywhere proved to be the best practice. But according to the conditions of the railway the locomotive may have to run at high speed on one section, and at low speed on the other, developing a great tractive force and necessitating a larger number of driving axles.

In such cases, a special single axle truck will be convenient. But from the replies we obtained, the range of speeds at which the single axle truck and the double axle bogie are used is not clear. On the Japanese Government Railways many passenger train locomotives giving the maximum speed up to 85 km. (52.8 miles) per hour are of the *Mogul* type, so it may well be said that the single axle truck is used for locomotives giving the maximum speed up to 85 km./h. The single axle truck of these locomotives is of two kinds; one in which the first driving wheel having a lateral play and the leading wheel are connected, and which acts in the same way as the double axle bogie does, such as the Krauss system, and the other of the ordinary type. The guiding effect of the former is found to be better than that of the latter. But the former tends to cause more wheel wear and is thus attended with maintenance difficulties.

The above-mentioned single axle truck is simpler in construction than the Krauss or Zara systems. It may be said that it is rather difficult to get a single axle truck which is simple in construction and gives the same running quality as the double axle bogie. But it is quite right to say that a single axle truck can be used for a considerably high speed, so far as the design is good.

IV. *Height of the centre of gravity :*

a) *maximum height allowed;*

b) *height preferred.*

The gist of the answers to this question is given in table 6. It is desirable to raise the centre of gravity for smooth locomotive running so far as there is no danger of overturning due to such raising. But the height of the centre of gravity which is allowable from the view-point of safety being dependent upon the limit of speed on curves, specified by various railways, no absolute maximum height can be determined. Table 6 shows that locomotives with 1 524-mm. (5-foot) centre of gravity height are run

TABLE

RAILWAYS. / Item.		Japanese Government.	Delaware and Hudson Railroad.	Federated Malay States Railways.
Gauge (G).		1 067	1 435	1 000
Height of centre of gravity (above rail surface).	Maximum allowable *mm.* (A).	1 590	2 032	...
	Desirable *mm.* (B).	1 585	1 829	...
	Now in pratice *mm.* (C).	1 587	1 829	1 524
Ratio of centre of gravity to gauge.	$\frac{A}{G}$	1.49	1.42	...
	$\frac{B}{G}$	1.485	1.28	...
	$\frac{C}{G}$	1.487	1.28	1.52

at the maximum speed of 64 km. (40 miles) per hour on the Federated Malay States Railways (metre gauge). This speed is rather too low to become a subject of discussion in which high-speed train service is dealt with. The highest centre of gravity of locomotives on 1 067-mm. (3 ft. 6 in.) gauge railways is attributed to the Japanese Government Railways. It is 1 590 mm. (5 ft. 2 19/32 in.), and the locomotive runs at the maximum speed of 100 km. (62 miles) per hour. So, these figures may be regarded as the highest of those for narrow-gauge railways. As for the height of the centre of gravity on the railways 1 435 mm. (4 ft. 8 1/2 in.) or over in gauge, the Illinois Central Railroad is of opinion that the maximum height of the centre of gravity should be 2 200 mm. (7 ft. 3 in.) but the highest one now in practice is that of the locomotives of the Pennsylvania Railroad, which is 2 030 mm. (6 ft. 8 in.) high. The ratio of the height of the centre of gravity to the gauge is assumed as representing the factor tending to the overturning of locomotives, the values being given in table 6. The ratio, 1/1.49, for the Japanese Government Railways comes first so far as the narrow-gauge railways, except the Federated Malay States Railways where the speed is low, are concerned. In spite of such a height, locomotives are run in safety on the said Japanese railways. The minimum value for the railways of 1 435-mm. gauge now operated is 1/1.41. If, on railways of 1 435-mm. (4 ft. 8 1/2 in.) gauge, the maximum height of the centre of gravity were raised to about 2 130 mm. (7 feet), as supported by the Kansas City Southern Railway, the ratio would become 1/1.48, and still the locomotive would run in safety, though there is some difference in speed as compared with the Japanese Government Railways. Summing up the various opinions, it seems that at present the maximum allowable ratio is about 1/1.5 from the view-point of safety.

Baltimore and io Railroad.	South Indian Railways.	Reading Company.	Canadian Pacific Railway.	Government Railways of Chosen.	New Zealand Government Railways.	British Railways Railway Clearing House).	Central of Georgia Railway.
1 435	1 676	1 435	1 435	1 435	1 067	1 435	1 435
...	...	2 032	...	...	...	...	1 905
under 1 943	...	under 1 829	under 2 032	...	above 1 359	...	1 829—1 905
1 943	1 778	1 964	1 880—1 981	1 650	1 359	1 791	1 329
...	...	1.42	...	...	...	...	1.33
under 1.35	...	under 1.27	under 1.42	...	above 1.27	...	1.27—1.33
1.35	1.06	1.37	1.31—1.38	1.15	1.27	1.25	0.93

TABLE

RAILWAYS. / Item.		Madrass and Southern Mahratta Railways.	New South Wales Government Railways.	Railways of China.
Gauge (G).		1 435	1 435	1 435
Height of centre of gravity (above rail surface).	Maximum allowable *mm.* (A).	○ 1 524 ⊗ 1 981	...	2 007
	Desirable, *mm.* (B).	...	...	under 2 007
	Now in practice, *mm.* (C).	1 981	1 626	1 981
Ratio of centre of gravity to gauge.	$\frac{A}{G}$	...	...	1.40
	$\frac{B}{G}$	...	...	under 1.40
	$\frac{C}{G}$	1.38	1.13	1.38

○ For standard gauge.
⊗ For broad gauge.
✱ No limit is specified, but this is considered proper.
+ On curved sections, the speed is governed by the height of the center of gravity.

V. *Arrangement and number of steam cylinders.*

The answers to this question are the same as those given in the table for Question 1. It will be seen that only a few railways have 3-cylinder and 4-cylinder locomotives in service, while all others adopt locomotives with 2 outside cylinders.

If locomotives with 2 outside cylinders are adopted for high speed train working, the distance from centre to centre of the two cylinders will become much smaller and the moment of cylinder force due to the phase difference of cylinder force will remarkably decrease. This fact will naturally lead to much less serpentine motion which is peculiar to locomotives, and contribute much to smooth running. As to the disadvantages of inside cylinders, the inspection and repairs are more difficult on account of all the moving parts being inside the frame, and driving crank axles have to be used. The common saying, « Simple is best », well applies to mechanisms such as locomotives. It is perhaps for this reason that inside cylinders are not generally favoured. But is is clear that the running quality of the 4-cylinder balanced locomotive or the 3-cylinder locomotive is better that that of the ordinary 2-cylinder locomotive.

When a high centre of gravity is adopted, it is desirable that such construction as will reduce the unduly large moment should be resorted to. The use of the inside cylinder, in spite of its rather complex construction, may be re-

ntinued.)

ansas City Southern Railways.	New York Central Lines.	Buenos Ayres and Pacific Railway.	South Manchuria Railways.	Pennsylvania Railroad.	Illinois Central System.	Richmond, Fredericksburg and Potomac Railroad.	Δ Wabash Railways.
1 435	1 435	1 676	1 435	1 435	1 435	1 435	...
- 2 130	...	...	2 000	2 200	2 030	...	...
+	1 924 1 207 (Elec. loc.).	...	1 850	2 200	1 680	...	...
...	1 924	1 985	1 850	...	2 030	1 930—1 980	...
1.48	...	...	1.40	1.53	1.42	...	...
...	1.34	...	1.29	1.53	1.17	...	...
...	1.34	1.18	1.29	...	1.42	1.35—1.38	...

Δ We do not pay any attention to the height of the center of gravity in designing locomotives, our height is usually governed by the maximum clearance height permissible for the engine as a whole.

commended from the view-point of the safety at high speeds.

VI. — *Designs for minimizing the unsprung weight.*

Table 7 is the summary statement of the answers to this question. All the reporting railways are making exact calculations in the designs in order to reduce the unsprung weight as far as it is permissible from the view-point of strength. For this purpose they make use of special steels for connecting rods, coupling rods, crank-pins, axles, etc., and some of them use hollow axles.

The Delaware and Hudson Railroad and the New York Central Lines use crank-pins and connecting rods of special steel. Hollow driving axles are adopted by the Kansas City Southern Railway. Hollow crank-pins and axles of special steels are in use on the Canadian National Railways. On the North Western Railway (India), connecting and coupling rods of special steels are applied to special locomotives. On the Japanese Government Railways, the principal locomotives have connecting rods of special steels, and have axles, coupling rods and crank-pins of forged steel of good quality, for minimizing the weight. Formerly crank-axles of carbon-vanadium steel were used by the same railway for 3-cylinder locomotives, but it was found that, with such axles, hair cracks are often produced in the journal as a result of a hot box, and gradually

TABLE 7.

RAILWAYS.	*Means of reducing the weight under the bearing springs.*
Japanese Government Railways . .	Special steels for connecting rods and forged steel of good quality for wheel axles and crank pins.
Delaware and Hudson Railroad . .	Spring saddles, driving axle boxes and wheel centres are made of cast steel of high tensile strength. Driving wheel axles, crank-pins and connecting rods are made of heat-treated alloy steels (chrome, vanadium, nickel and other steels).
Reading Company	Trucks as light as possible are used, no other special measures being taken.
Canadian Pacific Railway	No investigations have been made for this purpose. This railway interprets the weight under the bearing springs as that of wheels, axle boxes, axle bearings, etc. But the strength of wheels is the most important. On this railway the weight of these parts is rather being increased for the purpose of ensuring higher speed and more tractive force.
British Railways (Ry. Cl. H.) . . .	Alloy steels are used for reducing the weight so far as the strength is not decreased thereby.
Central of Georgia Railway	Wheel centres, driving axle-boxes and other parts are made of cast steel for reducing the weight, but not at the sacrifice of the required strength.
New South Wales Government Railways.	No special measures are being contemplated for reducing the weight under the bearing springs of locomotives. The weight under the bearing springs of goods wagons and passenger carriages is made small so far as the safety is not affected; no alloy steels are used.
Kansas City Southern Railway . .	Hollow axles are applied to driving wheels.
New York Central Lines	The weight under the bearing springs is nearly 12 % of the total weight of a locomotive in working order. With a view to reducing the weight under the bearing springs, driving axles are made hollow, the driving wheel centres are made of cast steel, and crank-pins and connecting rods are made of alloy steels. Other parts are designed so as to increase the strength by using materials as light as possible.
Canadian National Railways . . .	Running parts are designed in such a way that the greatest strength may be obtained with materials as light as possible. Crank-pins and wheel axles, of alloy steel, are made hollow.
North Western Railway (India) . .	Connecting rods and coupling rods of alloy steel are used.
Wabash Railway	No special designs for reducing the weight under the bearing springs except that we make use of alloy steels and take advantage to some extent of reduced section.

grow radially larger, thus making it necessary to withdraw the axles so affected, from service. Series of investigations were carried out on defective axles to find the cause of defects, but so far without result. Consequently carbon-vanadium steel is being replaced by carbon steel.

VII. *Designs of the construction of electric locomotives for minimizing the unsprung weight.*

Unfortunately, we received no answers worth mentioning to this question. Few of the railways replying use electric locomotives for high-speed train working.

On the Japanese Government Railways, where the nose suspension type is adopted as the standard construction of the electric locomotive, leading truck wheels are preferred, whose use is infrequent in other countries. The object of the leading truck is to reduce the weight on the driving wheels. It is difficult to decrease the unsprung weight in the case of the nose suspension type. Therefore, the above-mentioned measures have to be adopted for the same reasons as the reduction of the unsprung weight. Moreover, the use of the leading truck wheels will minimize the effect of rotation round the vertical pivot of the driving truck upon the rail and has a good effect on the high-speed train service.

VIII. *Amount of the spring deflection and types of the spring suspension.*

The answers to this question are summarized in table 8. For the purpose of ensuring smooth running of locomotives, it is desirable to make the deflection of the bearing springs under the maximum static load as large as possible. But since the deflection of the bearing springs is limited necessarily by spans, dimensions of plates and allowable bending stresses of the spring which are adopted as standards by different railways, the deflection cannot be determined independently of these factors. The figures given in this table are widely varied, ranging from 23.8 mm. to 88.9 mm. (0.937 to 3.5 inches) for the driving wheel springs. Generally, they are within the limits of 40 mm. to 60 mm. (1.57 to 2.36 inches). This may be good practice. Though it is desirable to have a large deflection, it often can be obtained only by making the allowable stress high, which may cause the breakage of the springs. If the deflection is too small, the variation of load on the spring will be great and may induce also the breakage of the spring. It is a common practice on the Japanese Government Railways, to keep the allowable stress as low as 3 500 kgr./cm² (49 700 lb. per sq. inch), when a deflection of about 40 mm. (1.57 inch) is obtained.

IX. *Regulations concerning the cross-section of worn wheel flanges, as for instance, those concerning the thickness, angles of the flange surface to the vertical, sharp point, etc.*

Table 9 covers the principal points of the answers to this question. While the flange form of the locomotive wheel type for high speed service is perhaps always maintained in as good a condition as possible, it is necessary to know the flange form of worn tyres which may tend to derailment. Nevertheless we received no answers on this point. The Japanese Government Railways in Japan proper and in Chosen, the Delaware and Hudson Railroad, the New York Central Lines, the Canadian National Railways, the Pennsylvania Railroad and the Illinois Central Railroad are the only railways where the wear limits relative to the angle of the flange surface to the vertical, thickness of the flange and the sharp points are specified, though these are the most important factors affecting derailments.

All these railways, except the Japanese Government Railways express the angle of the flange surface to the vertical and the sharp points in amount of vertical wear.

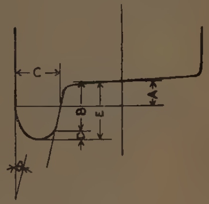
The railways where the limits of the thickness of flanges are fixed are the South Indian Railway, Canadian Pacific Railway, New Zealand Government Railways, South African Railways and Harbours, New South Wales Government Railways, Chinese Government Railways, Buenos Ayres and Pacific Railway, Nigerian Railway, North Western Railway (India) and South Manchuria Railway.

The only railway where the limits of sharp points are specified is the Burma Railways. Although limits are fixed by

TABLE 8.

RAILWAYS.	Deflection of bearing springs, *mm.*	System of suspension of bearing springs.
Japanese Government Railways	40.0	3-point.
Delaware and Hudson Railroad	Driving wheel 63.5 Leading truck 38.1 Trailing wheel 95.3	3-point.
Baltimore and Ohio Railroad	Driving wheel 41.3—44.5	3-point.
Norfolk and Western Railway	28.6—44.5	3-point.
Reading Company	...	3-point.
Canadian Pacific Railway	Driving wheel 60.3 Leading truck 57.2 Trailing wheel 60.3	3-point.
Government Railways of Chosen	54	3-point.
Cordoba Central Railway	Driving wheel 25.4—34.9 Leading truck 28.6 Trailing wheel 12.7—15.9	...
British Railways (Ry. Cl. H.)	Driving wheel 3.88—4.38/t. Leading truck 3.6/t.	...
Central of Georgia Railway	About 25.4	3-point.
Madras and Southern Mahratta Railway.	Driving wheel 61.9/7.5 t. Leading truck 63.5/9.1 t.	3-point.
South African Railways and Harbours.	46/7.93 t.	3-point.
New South Wales Government Railways.	Driving wheel 23.8 Leading truck 19.1	...
Railways of China	35	...
Sudan Government Railways	...	4-point.
Kansas City Southern Railway	50.8	...
New York Central Lines	Leading truck 44.5 Driving wheel 66.7 Trailing wheel 49.2 Tender wheel 36.5	3-point.
Canadian National Railways	...	3-point.
Buenos Ayres and Pacific Railway	Bogie 20.8/t. Driving wheel 7.0/t. Trailing wheel 5.05/t.	...
Nigerian Railway	76.2	5-point
North Western Railway (India)	6.4/t.	...
Burma Railways	8.3 t. In working order 31.8	...
South Manchuria Railway	Driving wheel 62.7 Leading truck 53.5 Trailing wheel 77.5	3-point.
Pennsylvania Railroad	...	3-point.
Illinois Central System	Driving wheel 75—50	3-point.
Richmond, Fredericksburg and Potomac Railroad.	45	3-point.
Wabash Railway	57.2	3-point.

TABLE 9.

RAILWAYS.	A	B (θ=0)	C	D	E	θ	Remarks.
apanese Government Railways	10	...	21	1.5	...	< 17° and D < 3mm	
elaware and Hudson Railroad	9.5	25.4	23.8	...	38.1	...	
outh Indian Railway	...	...	15 9	...	...	...	
anadian Pacific Railway	...	...	23.8	...	38.1	...	
overnment Railways of Chosen	...	22	23	...	35	...	
ailways of China	9	...	24	...	...	...	
anadian National Railways	...	...	23.8	...	38.1	...	
uenos Ayres and Pacific Railway	...	...	19	...	34	...	
igerian Railway	9.5	...	19.8	...	...	...	
orth Western Railway (India)	12.7	...	15.9	..	...	...	
orfolk and Western Railway	...	...	...	...	..	...	Governed entirely by Interstate Commerce Commission Regulations.
eading Company	...	...	...	...	. .	. .	
ew Zealand Government Railways.	...	...	○ 15.9	...	33.3	...	○ At the length 14.3 mm. from the top of flange.
entral of Georgia Railway	...	...	...	...	...	...	Governed entirely by Interstate Commerce Commission Regulations.
outh African Railways and Harbours.	...	...	□● 15.9 □● 19.1	...	...	...	□ At the length 14.3 mm. from the top of flange. ● Limit taken out of service.
ew South Wales Government Railways.	...	...	22.2 ⊗ 23.8	...	33.3	...	⊗ For electric motor bogies.
ew York Central Lines	...	25.4	23.8	...	38.1	. .	
urma Railways	...	...	...	3.18	...	...	
outh Manchuria Railway	...	...	23	...	35	...	
ennsylvania Railroad	...	25.4	23.8	...	38.1	...	
llinois Central System	...	25 4	23.8	...	38.1	...	
ichmond, Fredericksburg and Potomac Railroad.	...	...	23.8	...	...	...	
abash Railway	.	25.4	23.8	...	38.1	...	

most of the railways as to the height of flange, yet actually tyres are seldom re-turned in compliance with the specified limits of height. Further, though it seems that the wear limits relative to the thickness of tyres are specified by each railway, no reference is here made to them, as they have no bearing upon this question.

The investigations made on this problem by the Japanese Government Railways have led to valuable conclusions, which have become regulations governing all the rolling stock for some years (see Question 3).

Wheels, with the flange surface facing the rail worn in a straight line and with the point produced by this wear

on the flange contour line found under any of the following conditions shall not be used in such a state :

1. when the distance as measured along the wheel diameter from the sharp point to the extremity of the flange is less than 1.5 mm. (0.059 inch) (see fig. 1);

2. when the above-mentioned distance is less than 3 mm. (0.118 inch), and the angle between the worn part which has become straight and the inside flat surface of the wheel is less than 17° (see fig. 2).

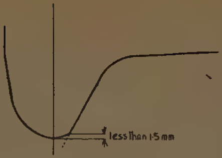


Fig. 1.

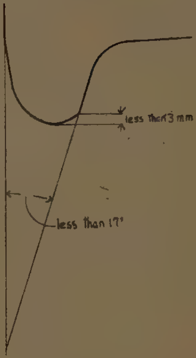


Fig. 2.

X. *Advantages and amount, if any, of the conicity of the wheel tread.*

We received answers to this question from 26 railway administrations, their import being almost the same (see table 10).

TABLE 10.

RAILWAYS.	*Advantages and amount of the conicity of the wheel tread.*
Japanese Government Railways	Conicity of the wheel tread keeps the centre line of the rolling stock along that of the track, and reduces flange wear. On curved lines, the body of the rolling stock is pushed outwards, and the slip of the wheels is naturally decreased over the different lengths of inner and outer rails when vehicles are running through curves. The conical tread wears longer. The amount of conicity is 1/20.
Federated Malay States Railways	While a train is running through a curve, axle of wheels moves laterally and wheels naturally make adjustment of the difference in length between inner and outer rails. The life of the wheels, which is necessarily affected by wear of the tread, is made longer by the conicity.
Baltimore and Ohio Railroad	Conicity is desirable from the view-point of reducing the possibility of derailment and also of ensuring smooth running of rolling stock over curved lines.
South Indian Railway	The amount of conicity is 1/20. When a train runs through a curve, rolling stock is pushed outwards and runs smoothly owing to the difference in diameter up to those parts of the tread of two wheels on the same axle which come in contact with inner and outer rails. Further, on a straight line, the center line of the rolling stock tends to be kept on that of the track.

TABLE 10. (*Continued*).

Norfolk and Western Railway . . .	In the opinion of this railway, advantages of conicity are doubtful, since the tread is gradually worn and the conicity deformed.
Reading Company	In compliance with the standard established by the A. R. A. the amount of conicity is specified as 1/20. With conicity of the wheel tread, concave wear of the tread is avoided and the life of wheels is made longer.
Canadian Pacific Railway	The amount of conicity stands at 1/20 in accordance with the standard adopted by the A.R.A. The conicity keeps the centre line of rolling stock along that of the track. It also reduces the slip between rail and wheel on a curved line.
New Zeeland Government Railways .	The conicity stands at 1/20.
British Railways (Ry. Cl. H.) . . .	1/20 is amount of conicity. Conicity is intended to keep the centre line of the rolling stock along that of the track.
Central of Georgia Railway	1/20 is amount of conicity.
Sudan Government Railways . . .	1/20 is amount of conicity.
Kansas City Southern Railway . .	Amount of conicity is 1/20. With the conical wheel tread, the lateral pressure on track and disagreable movement of rolling stock at high speeds can be avoided. But the conicity cannot be kept long.
New York Central Lines	1/38 is amount of conicity. Experiences so far gained show this 1/38 to be preferable for reducing wear of tyre. The above applies to the case of electric locomotives.
Canadian National Railways . . .	The American standard is adopted. By the conicity, the slip of wheels on curves is reduced and the centre line of the body of rolling stock is kept along that of track. The amount is 1/20.
Buenos Ayres and Pacific Railway .	On a straight and level line wheels are supported without using the flange. Lateral movement of wheels on curves is reduced. The amount of conicity stands at 1/20.
Nigerian Railway	The amount of conicity is 1/20.
North Western Railway (India) . .	The amount is conicity is 1/20. By the conicity, wear of flanges and rails is reduced.
Burma Railways	The amount is conicity is 1/20.
South Manchuria Railway	The amount is conicity is 1/20.
Pennsylvania Railroad	The amount is conicity is 1/20.
Illinois Central System	The amount is conicity is 1/20.
Richmond, Fredericksburg and Potomac Railroad.	The amount is conicity is 1/20.
Wabash Railway	The amount of conicity is 1/20. This conicity gives a certain centering effect to a truck, and also permits of more wear and greater mileage for a tyre between renewals.

The advantages of the conicity of the tread of tyres are as follows :

a) It keeps the centre line of the rolling stock always along that of the track on a straight line. It therefore reduces the wear of the flange and contributes towards safe working.

b) As, on a curved line, the body of the rolling stock is pushed outwards, the outer rail comes in contact with that part of the wheel tread which has a larger diameter, and the inner rail touches the tyre on the part with a smaller diameter, thus reducing the wheel slip;

c) In service the tread tends to be gradually worn into concave form along the centre line on its circumferential surface. So, the conical tread wears longer than the cylindrical.

The ordinary amount of conicity is 1/20. The reasons for this appear to be as follows :

In England, which has the longest history of railway working in the world, rails have, since early times, been laid with an inward inclination of 1/20 and the tyre tread has also had a conicity of 1/20, so as to be adapted to the rails. This example has been followed by other countries and the 1/20 conicity has been and is still used even where rails are laid horizontally. Fortunately, this inclination gives good results.

A few railways are of the opinion that the above-mentioned advantages of the conicity are doubtful, because the tread, even if it is conical at first, will before long be deformed. In fact, when we consider the quality of running, it is a question whether the conical tread is always preferable. The Japanese Government Railways have made experiments for determining comparative vibrations of passenger carriages having conical and cylindrical treads. The result of the experiments will be described in a later section, the conclusion being that smoother running was obtained by the cylindrical tread, though occasionally larger vibrations took place.

But on account of the various aforesaid advantages the conical tread is still used.

Question 3. — *Please let us know the results of experiments or researches on the subjects in Question 2, if any.*

It is a matter of regret that we have received very few answers to this question.

As to Question 2-II, the Reading Company says that the investigations made by the same company into the dynamic effect due to counterbalancing showed the maximum limit to be 50 % of the weight upon the wheel. The Canadian Pacific Railway has reported with reference to counterbalancing and dynamic effect that it obtained the results mentioned in the section on Question 2-II by experiments on locomotives with and without cross-balancing, as well as by its daily experiences.

A valuable report submitted by the Japanese Government Railways on Question 2-IX is reproduced in a separate section.

As to Question 2-X, the Norfolk and Western Railway has reported that the results of various experiments showed the conicity of 1 in 20 with a chamfer of the American standard contour to be the best.

The types of conicity covered by the experiments were as follows :

a) 1 in 20, straight taper, without chamfer;

b) 1 in 20 with chamfer ;

c) 1 in 13, straight taper, without chamfer.

d) 1 in 38, straight taper, without chamfer.

As regards this question, the Japanese Government Railways have reported on the effect which a conical (1/20) tyre tread and a cylindrical one have upon the vibration of rolling stock. The report is given in another separate section.

* * *

Report of the Japanese Government Railways.

Regulations concerning the cross-section of worn wheel flanges.

Limits to the wear of tyre flanges.

The limits to the wear of wheel flanges on the Japanese Government Railways, are as follows :

The wheels, with the flange surface facing the rail worn in a straight line and with the point produced by this wear on the flange contour line found under any of the following conditions shall not be used in this state :

1. when the distance as measured along the wheel diameter from the sharp point to the extremity of the flange is less than 1.5 mm. (0.059 inch) (see fig. 1) ;

2. when the above-mentioned distance is less than 3 mm. (0.118 inch) and the angle between the worn part which has become straight and the inside flat surface of the wheel is less than 17° (see fig. 2).

The above limits have been established from 163 flange sections from a number of vehicles, the form of the worn flanges being considered to be the cause of the derailments which actually took place.

The principal reasons for the foregoing regulations are as follows :

« A », « B », « C » and « θ » as shown

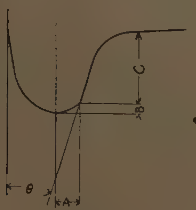


Fig. 3.

in figure 3 were measured for the aforesaid 163 flange sections. Figure 4 shows the respective integrated percentages of each of « A », « B », « C » and « θ » as measured.

These percentages may be regarded not only as showing the ratios of the number of cases not complying with the specifications when limits of flange wear are specified, but they suggest that, if flanges which do not comply with the specifications are correctly re-turned most of them can be place again in service.

The following nine proposals (table 11) may be made as to the dimension limits for the conflicting cases of 51 % to 77 % as given in figure 4.

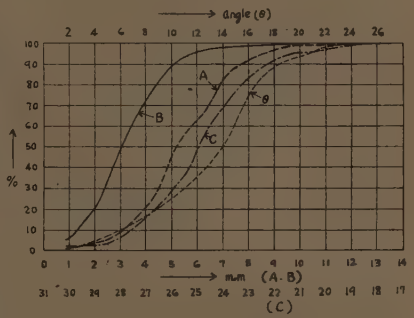


Fig. 4.

While a comparative study of the above proposals may show the first, second and third to be simple and convenient, flanges do not always keep their original form during wear, in other words, they do not wear in the same way as (*d*) in figure 5, but the wear they undergo deforms them in such ways as are shown by (*a*), (*b*) and (*c*). These three proposals, therefore, are not of great value. The fifth is simple and can prevent wear like (*a*) and (*b*), but is ineffective against wear like (*c*). The sixth, if A and θ are limited, can prevent the wear illustrated by (*c*), but not the wear illustrated by (*a*). The seventh, B and θ being specified, is ineffective against the wear of those types of which

TABLE 11.

Proposal.		A.	B.	C.	θ.	Ratio in %.
I	1	6.4	...	...	...	69
	2	5.6	...	...	...	58
II	1	...	4.0	...	...	74
	2	...	3.0	...	...	53
III	1	...	..	23.8	...	72
	2	...	...	24.6	...	57
IV	1	...	...	...	16°	74
	2	...	...	...	15°	60
	3	...	...	...	14°	51
V	1	6.4	3.0	..	...	77
	2	5.6	2.4	...	...	63
	3	4.8	2.4	...	..	52
	4	5.6	1.5	...	...	60
VI	1	4.8	...	..	15°	76
	2	4.0	...	...	15°	68
	3	4.8	...	...	14°	71
	4	4.0	...	...	14°	60
VII	1	...	2.4	...	15°	77
	2	...	1.5	...	15°	68
	3	...	2.4	...	14°	70
	4	...	1.5	..	14°	59
VIII	1	...	...	25.4	15°	71
	2	...	...	25.4	14°	65
IX	1	4.8	2.4	...	15°	85
	2	4.0	1.5	...	15°	76

Note. — The above proposed limits are related to each of « A », « B », « C » and « θ » separately. As for instance, (1) of the eighth proposal means that either « C » is less than 25.4 mm. (1 inch) or « θ » is less than 15°.

A is small and the flange is of such a form that it tends to get on to the rail.

Though the eighth proposal is similar to the seventh, its weakness lies in the fact that uniform safety cannot be expected, if the wear of the tread is not good. Further, as each proposal from the fifth to the eighth is a combination of any two conditions of the first to the fourth, the dimensional requirements may somewhat be abated, in so far as the same results can be realized as are obtained by any one of them.

The ninth proposal is a combination of the three conditions of the first to the fourth. While it involves more points of measurement, it is effective against wear of various forms and has the advantage that its requirements as to the dimensions are not so strict.

If the limits were specified as in the foregoing proposals, the use of tyres, whose dimensions conflict with any one or two of these specifications, should be prohibited. As for instance, tyres of which both A and B are pretty large

should be put out of service, if θ is in conflict with the specifications. If this was done, even tyres that could be safely used, could not be used until they had been re-turned, so the number of re-turnings would be increased. In order to remove such difficulties, investigations must be made as to the possibility of establishing the wear limits in the case of combinations of different dimension limits.

a) Number and percentages of conflicts when B and θ are below given limits.

TABLE 12.

	Number of conflicts.			°/₀ of conflicts.		
	θ below 15°.	θ below 16°.	θ below 17°.	θ below 15°.	θ below 16°.	θ below 17°.
B below 1.5 *mm.*	34	41	43	21	25	26
B below 2.4 —	60	[illegible]	75	37	42	46
B below 3.0 —	[illegible]	97	105	53	59	64

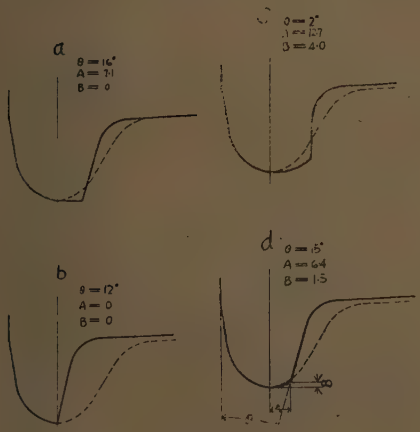


Fig. 5.

The above table suggests that even if either B or be in conflict with the specifications and an excessive wear takes place with respect to it, the tyre so worn may be used, as long as the other remains in accordance with the specifications.

In other words, it suggests that as long as is greater than 17°, the tyre may be used even if B be θ mm. [(*a*) and (*b*) in figure 5], and of a form tending, in itself, to cause derailment.

Such things, however, are not permissible in practice, and we cannot depend solely upon these limits.

b) If it is assumed that tyres whose θ is larger than the above, but whose B is below 1.5 mm. (0.059 inch), should not be used, the number of conflicts will be as follows :

TABLE 13.

	θ above 15°.	θ above 16°.	θ above 17°.
B below 1.5 *mm.*	20	13	11

If « a » and « b » are assumed as limits, the number of conflicts will become as follows :

TABLE 14.

	Number of conflicts.			% of conflicts.		
	θ below 15°.	θ below 16°.	θ below 17°.	θ below 15°.	θ below 16°.	θ below 17°.
B below 1.5 *mm.*	54	54	54	33	33	33
B below 2.4 —	80	82	86	49	50	53
B below 3.0 —	106	110	116	65	67	71

c) According to the combined wear limits given above, the percentage of conflicts varies with B and θ. If the ratio of conflicts of 70 % is assumed as the wear limit, the use of tyres whose B is below 1.5 mm. (0.059 inch) and of tyres whose B and θ are below 3.0 mm. (0.118 inch) and 17° respectively should be prohibited.

d) The above-mentioned limits do not cover A. We will now consider A.

The tyre, whose B is below 1.5 mm. and the tyre, whose B and θ are respectively below 3.0 mm. and 17°, being put aside, the number of conflicts as to A, and the total number of the conflicts as to A and of the conflicts as to the combined limits « c » will be as under :

TABLE 15.

A.	Number of conflicts as to A alone.	Total number of both conflicts.	Percentage.
3.0 *mm.*	2	118	72
4.0 —	5	123	75
4.8 —	7	130	80
5.6 —	8	138	85
6.4 —	25	163	100

Even if the limits as to A be taken into account, the percentage of conflicting cases is not much affected as long as A remains below 4.0 mm. (0.157 inch). In practice, therefore, the limits as to A need not be adopted. Generally, when that section of a flange which faces the rail is worn into a straight line, the tyre with such a flange which is small in A is also small in B. Therefore, if proper limits are set to B, these will suffice.

In view of these facts, as stated at the beginning of this report, the limits to the flange wear have been established by the Japanese Government Railways. These investigations show that if the sharp point is rounded off, this prevents derailment.

Report of the Japanese Government Railways on the conicity of the wheel tread.

A comparative study was made by the Japanese Government Railways of the vibration of the four-wheel bogie truck as affected by conical and cylindrical wheel treads. The result showed that there was generally no remarkable difference in vertical vibration between the two types of treads.

As to the lateral vibration, the cylindrical tread caused larger periods and more irregular vibrations, but of smaller amplitude. But in some cases, it caused larger lateral movement than the conical tread. This may be due to the fact that the wheels have less centering force

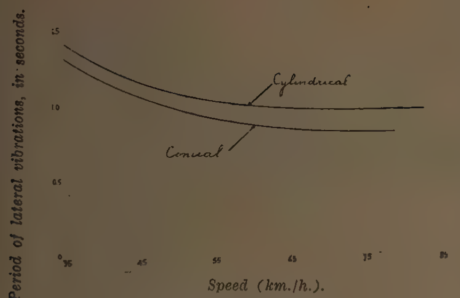


Fig. 6. — Comparative period of lateral vibrations.

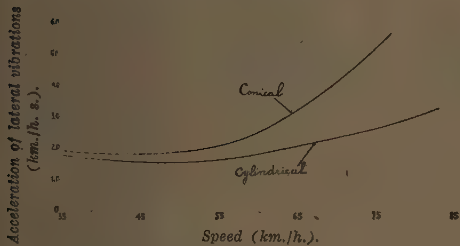


Fig. 7. — Comparative accelerations of lateral vibrations.

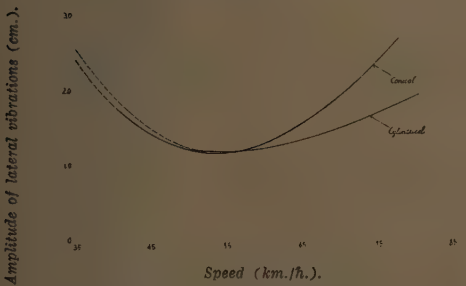


Fig. 8. — Comparative amplitudes of lateral vibrations.

with the cylindrical tread than with the conical. Generally, the sinuous motion of the truck is much less with the cylindrical tyre, and, therefore, the rolling of the car body, caused by the change of the direction of the sinuous motion of the truck, is small. Thus, smoother running was obtained with the cylindrical tread than with the conical. Notwithstanding this fact, the conical tread is still used on the same railway for the following reasons :

1. The cylindrical tread causes lateral movement of more irregularity, and occasionally even larger vibration than the conical tread.

2. Maintenance of flanges having the conical tread is easier.

3. With the conical tread, the concave wear of the tread is avoided and the life of the tyre is longer.

4. With the conical tread, the centering force is larger and, therefore, the train runs steadily.

5. The conical tread is more favourable for running through curves.

The diagrams obtained from the results of the experiments are shown in figures 9 and 10.

*
* *

Question 4. — *Please inform us of your opinion about the following points in the construction of locomotives used for high speed train working from the view-point of facilitating their running through curves :*

I. *Rigid wheel base and lateral movement of coupled axles.*
II. *Leading truck :*
   a) *controlling mechanism;*
   b) *initial controlling force;*
   c) *increase of the controlling force with respect to the deviation of the truck.*
III. *Height of the centre of gravity.*
IV. *Construction of the intermediate draw bar placed between the locomotive and tender.*
V. *Flange lubricators and the like.*
VI. *Others.*

I. *Rigid wheel base and lateral movement of coupled axles.*

So far as straight track lines are con-

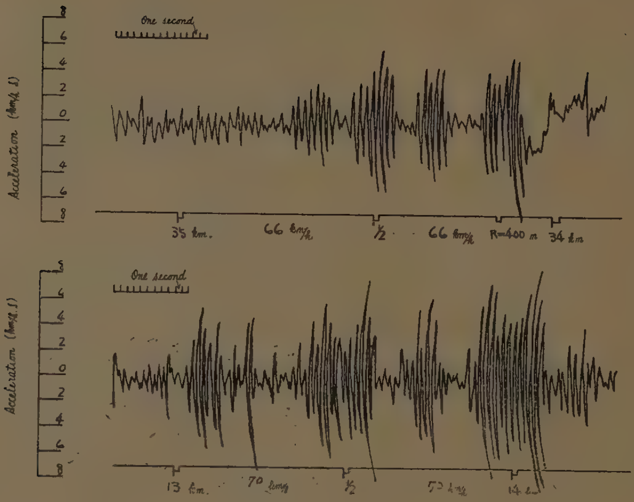


Fig. 9. — Continuity of lateral vibrations with the conical tread.

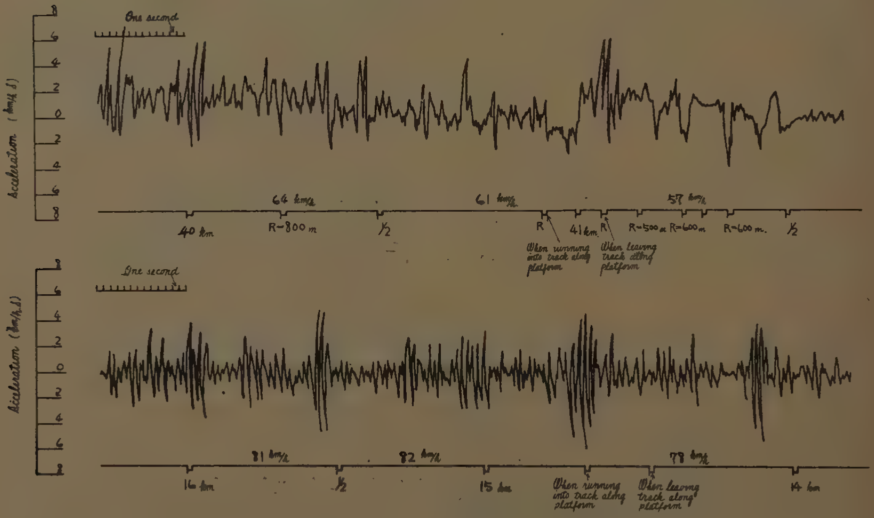


Fig. 10. — Discontinuity of lateral vibrations with the cylindrical tread.

TABLE 16.

Railways.	Rigid wheel base *mm.*	Lateral movement of coupled axle, *mm.* (from centre to one direction).
Japanese Government Railways	3 980	2 (new)—6 (wear limit).
Delaware and Hudson Railroad	4 572	Less than 9.6
Federated Malay States Railways	3 023	2
Baltimore and Ohio Railroad	4 267	3.2 (new)—9.6 (wear limit).
South Indian Railway	4 010 (broad gauge). 3 200 (metre gauge).	...
Norfolk and Western Railway	...	3.2 (new)—9.6 (wear limit).
Reading Company	4 216	Fore and rear driving wheels, 6.3 (new). Main and intermediate driving wheels, 3.2 (new)—9.6 (wear limit).
Canadian Pacific Railway	4 013	3.2 (new)—6.4 (wear limit).
Government Railways of Chosen	3 658	...
Cordoba Central Railway	...	3.2
British Railways (Ry. Cl. H.)	4 674	3.2
Madras and Southern Mahratta Railway.	4 343	3.2
South African Railways and Harbours.	3 353	...
New South Wales Government Railways.	4 267	...
Sudan Government Railways	4 470	No special clearance.
Kansas City Southern Railway	...	The same as in Rule 140 of the Interstate Commerce Commission's Regulations.
New York Central Lines	4 166	Main driving wheels, 3.2 (new)—9.6 (wear limit). Fore and rear driving wheels, 4.8 (new).
Buenos Ayres and Pacific Railway	...	1.6+normal fitting allowance between axle boxes and guides.
Nigerian Railway	3 505	1.6
North Western Railway (India)	...	1.2
South Manchuria Railway	3 960	3.0 (new)—7.5 (wear limit).
Pennsylvania Railroad	4 212	3.2
Illinois Central System	3 960	3.2
Richmond, Fredericksburg and Potomac Railroad.	3 960	9.5 (wear limit).
Wabash Railway	...	3.2 (new).

cerned, a larger rigid wheel base ensures smooth running and is in this respect to be preferred. But on a curve, a larger wheel base gives much larger resistance and is detrimental to safe running. Therefore, the rigid wheel must be determined in connection with the track conditions where the locomotive will be used. As far as the locomotives referred to in the answers we received are concerned, most of them have a rigid wheel base of about 4 000 mm., the largest being that of the Railway Clearing House (British Railways), which is 4 674 mm. The lateral movement which is allowed for the driving wheel of new locomotives for high speed train working is 1.2 to 6.3 mm. (0.047 to 2.48 inches) from the centre in one direction, but generally it is 2 to 3.2 mm. (0.079 to 1.26 inches). The greatest lateral movement allowed varies from 6 to 9.6 mm. (0.236 to 3.78 inches).

The amount of lateral movement which should be given to the driving wheel depends upon the rigid wheel base and the minimum curve radius.

Unless sufficient lateral play is given, hot boxes often result. But it is better not to give too large a lateral movement, as this is bad from the constructional point of view, and often the cause of more frequent repairs being necessary. Moreover, if the lateral movement is to be given to the first or last driving wheel, the amount of this must be determined by taking into account the possibility that the rigid wheel base may eventually be very small, which would be unfavourable for smooth running. The rigid wheel base and the lateral movement of the locomotives referred to in the answers received are summarized in table 16. These locomotives are good examples of general practice.

II. *Leading truck :*

a) *controlling mechanism;*

b) *initial controlling force;*

c) *increase of controlling force with respect to the deviation of the truck.*

The answers to the questions are summarized in tables 17, 18 and 19, and figure 11.

There are two kinds of controlling mechanism ; one being dependent upon spring force and the other upon gravity. But the latter type is used on almost all of the railways reporting to us.

The controlling mechanism which is dependent upon gravity may roughly be subdivided into two systems : the swing-link system, in which the controlling force varies according to the truck deviation, and the economy system or the inclined plane system, in which the controlling force always remains more or less constant. The former system is more generally used than the latter. At present the ordinary inclined plane system does not seem to be used. But the improved type equipped with rollers is used on the Japanese Government Railways with good results.

Now, the question arises as to what kind of controlling force is best.

TABLE 17.

RAILWAYS.	*Controlling mechanism of leading truck.*	
Japanese Government Railways	Economy system.	A
Delaware and Hudson Railroad	Economy system.	A
Federated Malay States Railways	Laminated spring.	C
Baltimore and Ohio Railroad	Heart link.	B
South Indian Railway	Coil spring.	D
Norfolk and Western Railway	Heart link or economy system.	B or A
Reading Company	Heart link.	B

Table 17. (*Continued.*)

Canadian Pacific Railway	Economy system.	A
Government Railways of Chosen . .	Heart link.	B
Cordoba Central Railway	Heart link.	B
Central of Georgia Railway	Economy system.	A
Madras and Southern Mahratta Railway.	Heart link.	B
South African Railways and Harbours.	Laminated spring.	C
New South Wales Government Railways.	Heart link.	B
Sudan Government Railways . . .	Coil spring.	D
Kansas City Southern Railway . .	Economy.	A
New York Central Lines	Heart link.	B
Canadian National Railways . . .	Controlling mechanism other than spring is desired.	...
Buenos Ayres and Pacific Railway .	Heart link.	B
Nigerian Railway	Coil spring.	D
North Western Railway (India) . .	Coil spring.	D
South Manchuria Railway	Economy system.	A
Pennsylvania Railroad	Heart link.	B
Illinois Central System	Economy system.	A
Richmond, Fredericksburg and Potomac Railroad.	Heart link.	B
Wabash Railway	Economy system.	A

Table 18.

RAILWAYS.	*Initial controlling force.*
Japanese Government Railways . .	5 000 kgr.—33 % of the load on leading truck.
Delaware and Hudson Railroad . .	8 640 kgr.
Reading Company	28 % of the load on leading truck.
Canadian Pacific Railway	40 % of the load on leading truck.
Railway Clearing House (Gt. Bn.) .	1 270 kgr.
Madras and Southern Mahratta Railway.	1 219 kgr.
South African Railways and Harbours.	1 280 kgr.
New South Wales Government Railways.	18.5 % of the load on leading truck.
Railways of China	Comparatively small.
New York Central Lines	40 % of the load on leading truck.
Canadian National Railways . . .	30—40 % of the load on leading truck.
Buenos Ayres and Pacific Railway .	2 750 kgr.
North Western Railway (India) . .	2 794 kgr.
South Manchuria Railway	40 % of the load on leading truck.
Pennsylvania Railroad	19.5 % and 31 % of the load on leading truck.
Illinois Central System	33 % of the load on leading truck.
Richmond, Fredericksburg and Potomac Railroad.	20 % of the load on leading truck.

TABLE 19.

RAILWAYS.	*Increase of the controlling force with respect to the deviation of the truck.*
Japanese Government Railways	Constant.
Delaware and Hudson Railroad	Constant.
Federated Malay States Railways	Increasing.
Baltimore and Ohio Railroad	Increasing.
South Indian Railways	Increasing.
Norfolk and Western Railway	Constant and increasing.
Reading Company	Increasing.
Canadian Pacific Railway	Constant.
Government Railways of Chosen	Increasing.
Cordoba Central Railway.	Increasing.
Railway Clearing House (Gt. Bn.)	Increasing.
Central of Georgia Railway	Constant.
Madras and Southern Mahratta Railway	Increasing.
South African Railways and Harbours	Increasing.
New South Wales Government Railways	Increasing.
Sudan Government Railways	Increasing.
Kansas City Southern Railway	Constant.
New York Central Lines	Increasing.
Canadian National Railways	Constant.
Buenos Ayres and Pacific Railway	Increasing.
Nigerian Railway	Increasing.
North Western Railway (India)	Increasing.
South Manchuria Railway	Constant.
Pennsylvania Railroad	Increasing.
Illinois Central System	Constant.
Richmond, Fredericksburg and Potomac Railroad	Increasing.
Wabash Railway	Constant.

As stated in the section on Question 4-I, it can easily be seen that the rigid wheel base which is made as large as possible is the most favourable for train working on a straight line.

Here the initial controlling force of the leading bogie which is made as strong as possible has the effect of making the rigid wheel base larger. If the initial controlling force were made as large as in the spring system or in the swing link system, where the controlling force varies according to the deviation of truck, the final controlling force would become too large and have a bad effect upon the running through curves.

Then let us take into consideration the running of locomotives through curves. It might seem more reasonable that the controlling force should be small when the truck deviation is small, as on curves having large radii of curvature, and the controlling force should be large when the truck deviation is large, as on curves having small radii of curvature. In fact, however, the speed of locomotives run-

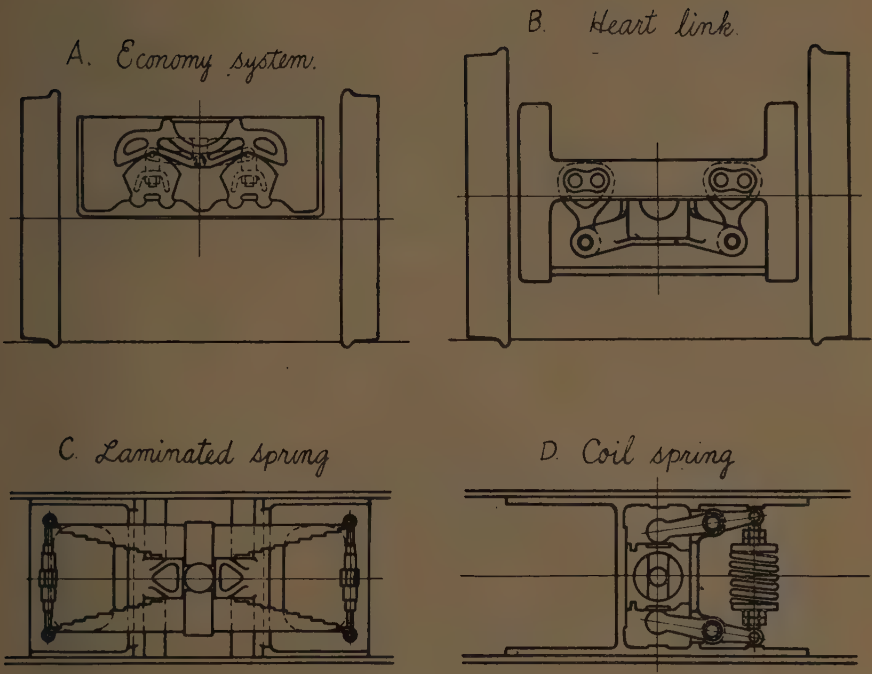


Fig. 11.

ning over a curve can generally be regarded as proportional to the radius of curvature, and, therefore, the angle of change of direction of locomotives within a unit length of time can be regarded as almost constant, for any radius of curvature. Thus, the angular acceleration may be considered to be invariable with the radius of curvature. Since this angular acceleration is due to the controlling force, it is desirable that the controlling force should be constant, independently of the radius of curvature, or, of the amount of the truck deviation. Again, statically considered, the controlling force required for changing the direction of locomotives is constant. So, it is preferable from the theoretical point of view that the controlling force required by locomotives should be constant and independent of the truck deviation.

At present the railways of Japan and of the United States are gradually adopting the constant controlling force system.

III. *Height of the centre of gravity.*

As stated in the section dealing with Question 2-IV, it is generally admitted that a higher centre of gravity is more

TABLE 20

RAILWAYS.	*Height of centre of gravity.*
Japanese Government Railways .	The height of the centre of gravity is not to exceed 1 590 mm. on account of curves of small radius, especially point curves without cant.
Delaware and Hudson Railroad .	It is preferred that the height of the centre of gravity be not more than 1 829 mm. and speed of locomotive limited sufficiently at curves where safe operation requires it.
Federated Malay States Railways .	1 524 mm.
Baltimore and Ohio Railroad . .	1 943 mm.
Reading Company	1 829 mm.
Canadian Pacific Railway . . .	2 032 mm.
Government Railways of Chosen .	1 650 mm.
Cordoba Central Railway . . .	2 076—2 185 mm.
British Railways (Ry. Cl. H.) . .	The height of the centre of gravity of locomotives in this country is such as to have little bearing on the question of speed in curves.
Central of Georgia Railway . . .	Recently it has been seen that a high centre of gravity, within certain limits, contributes to steadiness of running and diminishes the lateral pressure on the outer rail in curves. The load on the outside wheel is increased and, therefore, the resistance to derailment.
New South Wales Government Railways.	1 753 mm.
Railways of China	The lower the centre of gravity, the more stable will be the locomotive at high speed.
Kansas City Southern Railway .	In the design of locomotives considerable attention is directed towards keeping the height of the centre of gravity as low as consistent with suitable arrangement.
Canadian National Railways . .	When the proper relation exists between height of centre of gravity, truck construction and speed, a relatively high centre of gravity should be less destructive to track and wheel flanges than a lower one.
Buenos Ayres and Pacific Railway	The height of the centre of gravity should be kept within the limits defined in answer to Question 2 (IV). This in order that the reduction of weight on inner wheel due to centrifugal force in combination with the reduction due to dynamic augment of balance weights may not induce a condition where slipping of inner driving wheels would occur.
North Western Railway (India) .	The cant on curved lines is so designed that a locomotive having a height of centre of gravity up to 2 000 mm. can run over such lines, but at present the height of 1 800 to 1 850 mm. is considered to be proper.
Pennsylvania Railroad	2 030 mm.
Illinois Central System	2 200 mm.
Richmond, Fredericksburg and Potomac Railroad.	1 930—1 930 mm.

favourable as regards the smooth running of locomotives, and that the height of the centre of gravity within the limits given in the same section is satisfactory for safe running. As the radius of curvature, cant and speed limit vary with different railways, no definite safe limit for the height of the centre of gravity that is applicable to all locomotives can be determined. But the experience which one railway has as to the height of the centre of gravity is considered to be valuable to the other.

The answers from the various railways are given in table 20.

IV. *Design of the intermediate draw bar between the locomotive and tender.*

The intermediate draw bar between engine and tender should be of such construction as to permit the locomotive to enter a curve without excessive binding on the tender, at the same time ensuring close coupling — a suitable buffing arrangement located on the centre line being provided to facilitate this condition. So far as the answers to this question are concerned, the buffing devices may roughly be classified into the types which are given in table 21 and figure 12.

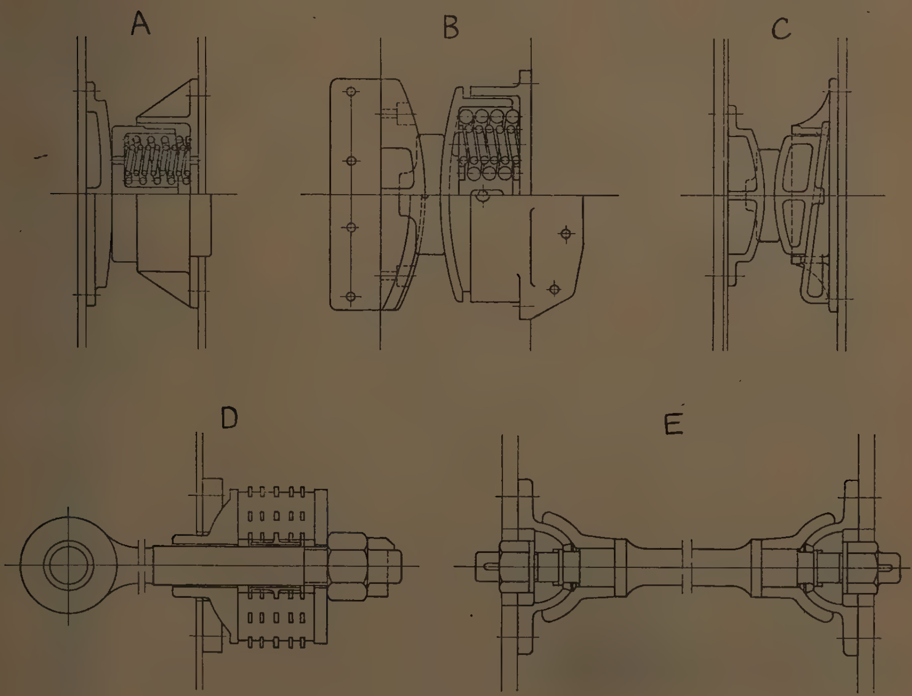


Fig. 12.

TABLE 21.

RAILWAYS.	*Construction of the intermediate draw bar placed between locomotive and tender.*
Japanese Government Railways	A-type buffer without safety bar.
Delaware and Hudson Railroad	Unit draw bar with safety bar device.
Federated Malay States Railways	E-type device.
Baltimore and Ohio Railroad	B-type buffer with safety bar device.
South Indian Railway	Goodall's articulated draw bar and coupling.
Norfolk and Western Railway	No experience with any special designs of draw bar.
Reading Company	Draw bar of flat type.
Canadian Pacific Railway	Draw bar of the laminated type with safety bar device.
Cordoba Central Railway	A-type buffer without safety bar.
British Railways (Ry. Cl. H.)	A-type buffer with safety bar device.
Central of Georgia Railway	Unit draw bar and safety bar device.
Madras and Southern Mahratta Railways.	Goodall's draw bar.
South African Railways and Harbours.	A-type buffer with safety chain device.
New South Wales Government Railways.	Unit draw bar system with safety bar device.
Railways of China	Ordinary draw bar with safety bar device.
Sudan Government Railways	A-type buffer.
Kansas City Southern Railway	B-type buffer with safety bar device.
New York Central Lines	B-type buffer with safety bar device.
Canadian National Railways	B-type buffer with safety bar device.
Buenos Ayres and Pacific Railway	D-type buffer.
Nigerian Railway	D-type buffer with safety device.
Burma Railways	Goodall's draw gear without intermediate buffer.
South Manchuria Railway	C-type buffer with safety bar device.
Pennsylvania Railroad	Ordinary draw bar with safety bar device.
Illinois Central System	C-type buffer with safety bar device.
Richmond, Fredericksburg and Potomac Railroad.	B-type buffer with safety device.
Wabash Railway	Ordinary draw bar with safety device.

Of these devices, A, B and C are the most common, but A has the disadvantage of somewhat disturbing the free motion of the locomotive. B, the radial type, is primarily of three-piece construction, consisting of an engine block, a tender block and a floating casting held between them. The engine and tender blocks are formed on a radius from their respective draw-pin centres, while the floating block is concave on both faces to retain contact with each casting throughout the range of movement. An adjustable spring located behind the tender block keeps all three castings in contact and provides the necessary cushioning against buffering shocks. Further, as the sliding surface can be lubricated, the free motion of the locomotive is not much disturbed. C is also

a radial buffer, but a wedge is used instead of the coil spring. It is so constructed as to ensure rigid connection between locomotive and tender and not to disturb the free motion of the locomotive. By using the wedge the locomotive and the tender are made into one body, and less vibration is produced than when the coil spring is used.

There are a number of railways where the safety bar device is adopted. But it may well be said that in practice absolutely no accident is caused by breakage of the draw bar, and, therefore, the safety bar device may be dispensed with.

V. *Flange lubricators and the like.*

The summary of the answers to this question is given in table 22.

There are many railways where flange oilers or similar devices are used for practical or experimental purposes to facilitate the running through curves of high speed locomotives. Lubrication of wheel flanges at the time a train is running through a curve not only decreases the running resistance and the danger of derailment, but it reduces wear of flanges and rails. These are great advantages.

TABLE 22.

RAILWAYS.	*Flange lubricators.*
Japanese Government Railways . .	Formerly oilers of various descriptions were experimentally applied, but now water sprinklers are used in their stead with good results.
Delaware and Hudson Railroad . .	Flanges of fore driving wheels are lubricated.
Baltimore and Ohio Railroad . . .	Flanges of driving wheels are lubricated on locomotives having a long wheel base.
South Indian Railway	The flange oilers are applied to the locomotives worked in mountainous districts of Nilgiri.
Norfolk and Western Railway . . .	Flange oilers are used for reducing wear of rails and flanges. They are not considered to have a bad effect upon the safety of trains hauled by high-speed locomotives through curves.
Reading Company	All the high-speed locomotives are fitted with flange lubricators.
Canadian Pacific Railway	Flange oilers have the advantage of reducing wear of rails and flanges. It seems more effective to have rails fitted with the apparatus than to install them on each locomotive. But the apparatus are not regarded as of great importance by this railway. They are used only in the districts where there are many curves of small radius .
Government Railways of Chosen . .	Experiments are in progress on apparatus designed by this railway.
British Railways (Ry. Cl. H.) . . .	Oilers are experimentally installed.
Central of Georgia Railway	Flange oilers are installed on locomotives of large tractive force. They considerably reduce wear of wheel flanges.
Madras and Southern Mahratta Railway.	Hasler's flange oiler is experimentally in use.
South African Railways and Harbours.	Experiments were often made on flange oilers, but with no satisfactory results. None are used at present.
New South Wales Government Railways.	Various kinds of flange oilers have been used, but with no good results.

TABLE 22. (*Continued.*)

Railways of China	Flange oilers are so arranged that they drop oil on the flange alone, and not on the tread. They are automatically opened and shut. Their value would be increased, if the quantitiy of oil to be dropped were automatically adjusted according to track conditions.
Kansas City Southern Railway . . .	Flange oilers are installed for driving wheels which are subjected to heavy wear. Use is made of various types manufactured in America. In all of them, the ball valve or the pendulum valve is opened due to centrifugal force at the time the locomotive is running through curves, and oil is thereby dropped on the flange.
New York Central Lines	Flange oilers are installed on some passenger locomotives. There are three types of oilers in use, that is, the Chicago, Hooper and Detroit.
Canadian National Railways . . .	It seems that there is no need for flange oilers on this railway, on which no sharp curves are found.
South Manchuria Railway	Automatic flange lubricators of the Detroit and Elliot types are used.
Pennsylvania Railroad	No flange oilers are in use.
Illinois Central System	Flange oilers of Detroit and pendulum types are adopted.
Richmond, Fredericksburg and Potomac Railroad.	No flange oilers are in use.

But as is clear from the purpose for which they are destined, flange lubricators should be automatic and accordingly of high sensitivity. This requires a construction of much complication and entails difficulties in maintenance. This seems to account for the fact that they have not been extensively used. The Japanese Government Railways have made investigations into the performance of flange oilers of various descriptions and found some of them to be good for the purpose. But for various reasons no flange oilers are now in use on the said railway where water is sprinkled on the rail part just in front of the leading driving wheels. As water is sprinkled continuously while the locomotive is running, the apparatus gives little trouble to the locomotive crew and is very simple in its construction. Its performance has proved satisfactory.

By the use of such apparatus the running resistance on straight lines, as well as flange wear on curved lines, has decreased, which in its turn has led to fuel economy. The comparative wear of flanges, when the water sprinkler is used and when it is not, is shown in table 23

TABLE 23 — A.

Amount of flange wear (in millimetres) per 10 000 kilometres run by locomotives.

Locomotive number.	Without water sprinkler.	With water sprinkler.
58 645	5.0	0.54
58 646	4.6	1.00
58 647	5.3	1.10
58 648	3.8	0.63
58 649	5.2	1.05
58 650	8.2	0.42
58 651	9.0	1.05
58 652	10 0	1.08
58 653	12.5	0.92
58 654	9.0	0.87
Mean.	7.26	0.86

(A) and (B). The amount of water consumption is very small, about 280 l. (62 Imp. gallons) per hour, and, therefore, the capacity of the tender usually remains little affected if the sprinkler is used. It is now installed not only on the locomotives for high-speed working but on all other locomotives of the Japanese Government Railways.

TABLE 23. — B.

Locomotive number.	With flange lubricator.	Locomotive number.	With water sprinkler.
59 686	0.92	19 692	0.87
19 629	1.05	19 628	0.85
Mean.	0 99	Mean.	0.86

Summary for Question III-A.

The locomotive for high speed service is of 4-6-2 or Pacific type, and on some lines where extremely large boiler capacity is required the 4-6-4 type is used. The guiding action of the 2-axle leading bogie is far better than that of the single axle truck and is especially suitable for the high-speed locomotive. There are several kinds of controlling devices of the leading truck, but that which exerts constant controlling force is preferable and seems to be favoured more and more.

As to driving wheels, 3 pairs seem to be sufficient, so far as the express trains are concerned. There may be railways where 4 pairs of driving wheels are required for high-speed train service. But in such a case, the diameter of the driving wheels is kept within certain limits, so that the boiler may not be excessively long.

The largest diameter of the driving wheels is 1 750 mm. (5 ft. 8 1/4 in.) for narrow gauge railways and 2 057 mm. (6 ft. 9 in.) for standard and broad gauge railways. The greater the diameter is, the more smoothly the locomotive runs and the higher the mechanical efficiency seems to be.

Therefore, it is recommended to make the diameter of the driving wheels as large as possible. Fears may be entertained lest the locomotive should tend to overturn, if the diameter is made so large. But the ratio of the track gauge to the height of the centre of gravity for the standard and broad gauges may be made smaller or the centre of gravity may be made higher, with no danger of overturning, as shown by the experience of the narrow gauge railways. Thus, it is quite possible to adopt a larger diameter for the driving wheels.

As to the cylinder arrangement, the 3-cylinder or 4-cylinder arrangement is recommended for smooth running of the locomotives, though such arrangements are not yet widely in use due to the rather more complicated construction. In fact, such construction should be adopted if the height of the centre of gravity is made high enough in comparison to the track gauge, owing to the large diameter of the driving wheels, as is the case with the narrow gauge on the Japanese Government Railways.

The system of spring suspension, though its standard practice varies according to the railways, is generally three-point, as this is considered the best.

It is a common practice to take into account the axle load and wheel spacing in the calculation of bridges, but not in that of track, though their effect upon the strength of track is being investigated by some railways. The wheel spacing of the 4-6-2 type is generally favourable for the track, so long as the axle load is not exceptionally large. It is therefore necessary to distribute properly the total weight upon the driving and carrying wheels. Thus, we can see that the 4-6-2 type locomotive, if properly designed, may be considered the best for high-speed train service from every point of view.

B. — Track resistance, widening of gauge, radius of curves, superelevation, transition curves, points and and crossings, check rails.

Question 1. — *We want to know the standard designs of the track of your railway for high-speed working of the standard locomotives mentioned in Question 1 in A. Please attach illustrations.*

We have received answers to this question from 29 railway administrations, the weight of their rails, number of sleepers and depth of ballast in track sections for high-speed train working being shown in table 1.

It will be seen from this table that the weight of rails laid in track sections for high speed train working of the standard gauge railways is generally 50 kgr./m. (100.8 lb. per yard) and over. The weight of rails of the Pennsylvania Railroad comes first, and amounts to 152 lb. per yard (75.4 kgr./m.). As for the weight of rails on the narrow gauge railways, the Japanese Government Railways have adopted 50-kgr./m. rails for the track section between Tokyo and Kobe to meet the increase of axle load (Question in A is to be referred to) as well as that of the train speed and to economize labour in the maintenance of the permanent way.

The average distance from centre to centre of sleepers in straight line sections is in most cases below 600 mm. (1 ft. 11 5/8 in.) for the standard gauge railways, while it is mostly 600 to 750 mm. (1 ft. 11 5/8 in. to 2 ft. 5 1/2 in.) for the narrow and broad gauge railways. As regards the depth of ballast, it is almost unvaried with the different narrow gauge railways, ranging from 200 to 250 mm. (8 to 10 inches) under the bottom of the sleepers, while it varies somewhat more widely for the standard gauge railways, the smallest being 152 mm. (6 inches), and the largest 457 mm. (18 inches).

Question 2. — *What methods are adopted by your railway for determining the strength of rails, fish-plates, tie-plates, spikes, sleepers, ballast, etc. on the section under the high-speed train working? We want to know the results of experiments on the subjects, too, if any.*

It is to be regretted that we did not receive as many answers as we had expected, as if the object for which the question was raised had not been well understood by the railways receiving our Questionnaire, and we desire further discussions to be held on the subject at the Congress.

The Japanese Government Railways made a series of investigations into the strength of railway tracks.

Static calculations of stresses in rail have been made by assuming the rail to be a continuous beam upon elastic supports, and the same assumption has been adopted for the calculation of stresses at rail joints. Further, as to the dynamical effect of train loads, we have, after more than 100 000 field measurements of rail stresses, reached the conclusion that all dynamic effects due to rolling stock will be covered by an increase of the static load effect by 1 % per 1 km. per hour increase in train speed.

Some of the experiments and the mathematical treatments made by the same railway regarding this subject are briefly described in the following :

a) Pressure distribution in ballast ;

b) Impact as measured by the ortheograph ;

c) Stresses in rail-joint.

a) *Pressure distribution in ballast.*

Investigations were carried out by laying a test track, whose construction and material were the same as those of the existing ordinary track, for the purpose of ascertaining how the pressure which has been applied on the surface of the ballast by the sleepers is distri-

buted in the ballast and over the road bed. The material used for ballast was chiefly river gravel. On this ballast were laid ordinary cross-sleepers 210 cm. (6 ft. 10 11/16 in.) in length, 20 cm. (8 inches) in width and 14 cm. (5 1/2 inches) in thickness. The measurement was effected after the ballast was made stable by lightly and uniformly tamping it and by applying pressure thereon several times. A number of earth pressure gauges of A and B types designed for the investigations were used for the measurement. Results of the experiment are summarized in the following.

Let p_c stand for the intensity of pressure on ballast at the middle of the width of a sleeper, x for the distance as measured from the middle in the direction of the width, and $p_c\left\{1-\left(\frac{2x}{b}\right)^3\right\}$ (where b is the width of the sleeper) for the intensity of pressure on ballast at any point under the sleeper, then P_m, the intensity of pressure in ballast under the sleeper will be expressed in the following equation, so far as the length of sleeper and the thickness of ballast are ordinary ones.

$$p_m = \frac{2pc}{\sqrt{\pi}}\left[\int_0^{\frac{bk}{2}} e^{-t^2}dt + \frac{4}{b^2k^3}\left\{\left(\frac{b^2k^3}{4}+1\right)e^{\frac{-b^2k^2}{4}}-1\right\}\right]$$

A measurement of the intensity of pressure in the ballast on the test tracks showed $k = \frac{1}{k} = \frac{1}{h-6}$ (The unit is the kilogramme-centimetre and $k = 0$ when the depth of ballast h is below 6 cm. (2.362 inches).

If the value of k is determined, the lateral distribution of the pressure in ballast will also be ascertained.

As the existing tracks on the Japanese Government Railways for the most part have 15 to 30 cm. (6 to 12 inches) depth of ballast and 60 to 80 cm (1 ft. 11 5/8 in. to 2 ft. 7 1/2 in.) between centres of sleepers, there is no effect upon the road bed by the adjacent sleepers.

b) *Impact as measured by the ortheograph.*

The amount of impact given by various locomotives on the track was measured with an ortheograph which was constructed on the same principle as that which was laid in the Erie test track by the General Electric Co. This ortheograph consisted on ten iron sleepers fitted with an apparatus for measuring the rail pressure on the sleeper and the side thrust given by wheels on the rail head. The rails were P. S. 50 kgr. (100.8 lb. per yard), and the track was straight. Table 2 shows the rail pressure by each wheel upon the bottom springs which had the greatest rate of increase with respect to the speed and the side thrust which had he greatest value as determined by the side spring at the time a C53 type steam locomotive ran over the ortheograph. With regard to other locomotives, measurements were also conducted and various results were obtained. From these results we can see that the impact of the driving wheel increases the wheel load by 1 % for an increase of speed of 1 km. (0.621 mile) per hour.

c) *Stresses in rail-joint.*

External forces acting upon fish-plates come from the rail head, the rail base or the bolt. These forces vary according to general conditions of track, as well as to fish-plates. Of these external forces, the most important is the pressure which the rail exerts upon fish-plates (see fig. 1). Stresses in fish-plates and rails near the joints are chiefly dependent upon this pressure.

TABLE 1.

RAILWAYS.	Gauge in mm.	Weight of rail, in kgr./m.	Number of sleepers.	Depth of ballast (mm.) as measured from the bottom of sleepers.
Federated Malay States Railways.	1 000	39.70 F. B. B. S.	13/12.20-m. rail.	229
Cordoba Central Railway . .	1 000	34.70	19/12.20-m. rail.	254
Burma Railways	1 000	29.80 B. S.	...	152
Madras and Southern Mahratta Railway.	1 000	29.80 R. F. F.	16/10.10-m. rail, 17/11-m. rail.	...
	1 676	37.20 F. F.	14/11-m. rail, 16/12.20-m. rail.	...
New Zealand Government Railways.	1 067	34.70 B. S.	18/12.80-m. rail (on curves 40.2 m. radius and over). 19/12.80-m. rail (on curves under 40.2 m. radius).	229
Sudan Government Railways .	1 067	37.20	14/11-m. rail.	...
South African Railways and Harbours.	1 067	39.70 B. S. 47.60 (future standard).	16/12.20-m. rail (on straights and on curves 21.2 radius and over). 17/12.20-m. rail (on sharp curves).	203 with sub-ballast.
Japanese Government Railways	1 067	49.60 A. R. A. 49.60 P. S.	18/12-m. rail (on level straights). 19/12-m. rail (on curves under 400 m. radius or on grades 1 in 66 and over). 20/12-m. rail (on curves under 400 m. radius with grades 1 in 66 and over, or, on grades 1 in 35 and over). 21/12-m. rail (on curves under 400 m. radius with grades 1 in 35 and over).	200
Delaware and Hudson Railroad	1 435	64.50 R. E.	...	330
Baltimore and Ohio Railroad .	1 435	64.50 R. E. 64.50 P. S.	22/11.90-m. rail.	229 to 305 with sub-ballast.

Canadian Pacific Railway . .	1 435	49.60 R. E.	1 875/km.	178
Government Railways of Chosen	1 435	49.60 P. S.	19/12-m. rail. 16/10-m. rail.	...
British Railways (Railw. Clearing House).	1 435	47.10 B. S.	24/18.30-m. rail. 18/13.70-m. rail.	...
Central of Georgia Railway . .	1 435	44.60 A. R. A. A.	24/11.90-m. rail.	203
New South Wales Government Railways.	1 435	49.60 A. S.	...	...
Chinese Government Railways	1 435	42.20	14/10-m. rail.	229
Kansas City Southern Railway	1 435	63.00 Dudley (future standard).	To be spaced 508 mm. centre to centre.	305 with 305 mm. sub-ballast.
New York Central Lines . . .	1 435	63.00 Dudley.	20/10.10-m. rail.	305 with 343 mm. sub-ballast.
Canadian National Railways .	1 435	64.50 R. E.—H. F.	...	152 to 305 with sub-ballast.
South Manchuria Railway . .	1 435	49.60 A. R. À.—A.	18/10-m. rail.	267
Pennsylvania Railroad . . .	1 435	75.40 P. S. 65.00 P. S.	20/10.10-m. rail. 22/11.90-m. rail. 26/13.70-m. rail.	457 with 305 mm. sub-ballast.
Illinois Central Railroad . . .	1 435	54.60 44.60 A. R. A.—A.	...	305
Wabash Railway	1 435	54.60 R. E.—H. F.	24/11.90-m. rail, 20/10.10-m. rail. 18/9.10-m. rail.	305 with 305 mm. sub-ballast.
Richmond, Fredericksburg and Potomac Railroad.	1 435	64.50	...	...
Buenos Ayres Western Railway.	1 676	49.60	1 477/km.	...
Buenos Ayres and Pacific Railway.	1 676	49.60	1 520/km.	...
North Western Railway (India)	1 676	44.60 B. S.	15/11-m. rail.	203

There are different forms of fish-plates, such as flat bars, angle bars and the like. In the case of angle bars, the deflection due to vertical bending moment is not in

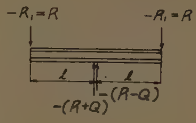


Fig. 1

the vertical direction. We will express in Φ this inclination of the neutral axis with respect to the horizontal axis.

Then, from this angle Φ and the properties of sections, an equivalent moment of inertia of section for the vertical deflection of fish-plates will be deduced. For the wheel loads applied to the track, we have considered twelve different ways in which the rail and the fish-plate act upon each other.

From the above data, the effective force acting upon the fish-plates will be obtained analytically or graphically as the case may be. Thus, the stresses in the fish-plate and the rail or the sinking of the rail joint or rail can be obtained.

The action of fish-plates differs remarkably according to the conditions of track. At present, 30 and 37 kgr. (60.5 and 74.6 lb. per yard) rails and angle bars of A. S. C. E. section as well as P. S. 50 kgr. (100.8 lb. per yard) rails fitted with flat bars are generally in use on the tracks of the Japanese Government Railways. Stresses were measured at several points of the rail joints, which were made with these rails and bars, in a laboratory, and of rail joints on actual tracks. Investigations having been also carried out into Φ and the ratio between the bending moment to which these joints were subjected and that to which rails were subjected, we found that fish-plates behave in special ways dependent upon the degree of screwing-up of the bolts and that the tension in the bolt is proportional to the torque on the nut.

With the angle bars now in service on the Japanese Government Railways' track, the torque is less than 700-800 kgr.-cm.

The ratio between twice the vertical bending moment to which rail joints are subjected and the vertical bending moment to which rail parts except those near the rail joints are subjected is 0.3-0.7 or about 0.5 on an average, in the case of the positive bending moment. But the stresses in fish-plates are still far larger than those in rails. In the case of the negative bending moment, it amounts to 0.3 to 1.65, averaging about 1.

The value of the negative bending moment to which the rail joints are subjected, therefore, comes very near that of the positive bending moment.

The stresses in the rail near the joint under moving wheel loads show special actions. When a wheel rolls over the track and the rail joint, we can see that the rolling surface of the wheel sinks and this surface is discontinuous at the rail joint. Figure 2 shows this discontinuity.

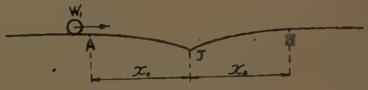


Fig. 2.

The low point of the rolling surface at the rail joint may be expressed by compound cosine curves for the sake of convenience.

When the wheel load rolls over this low spot of the track, the additional dynamic deflection of the rail or dynamic augment of stresses in the rails is very remarkable.

The differential equation of the motion of the wheel in the vertical direction is :

$$\frac{W_1}{g} \cdot \frac{d^2(y+h)}{dt^2} + cy = 0,$$

TABLE 2.

C53-type steam locomotive :
Rate of increase of rail pressure and side thrust.

		Speed, km. (*miles*) per hour	L_1	L_2	D_1	D_2	D_3	T_7	T_1	T_2	T_3	T_4
Rail part away from joint	Rate of increase of rail pressure (%).	50 (31)	36	19	23	2	33	31	31	26	52	19
		70 (43.5)	43	30	34	76	76	44	43	43	71	23
	Side thrust (kgr.) . . .	5 (3.1)	145	151	135	205	190	152	7	111	129	138
		50 (31)	159	172	176	208	298	191	146	144	156	156
		70 (43.5)	141	213	230	235	360	225	159	181	196	187
At joint	Rate of increase of rail pressure (%).	50 (31)	203	84	62	86	44	57	174	171	144	176
		70 (43.5)	361	108	79	94	58	82	241	292	223	220
	Side thrust (kgr.) . . .	5 (3.1)	230	199	255	253	318	321	108	155	215	274
		50 (31)	332	345	268	333	350	388	326	319	321	293
		70 (43.5)	345	350	288	350	336	380	326	326	298	270

where :

$\frac{W_1}{g}$ = unsprung mass of wheel,

h = variable depth of low spot,

y = additional deflection of rail under wheel,

c = vertical load necessary to produce a deflection to unity.

The limiting conditions are as follows :

at A

$$y = 0 \qquad \frac{dy}{dt} = 0$$

at J in J^B

$$y = y_{J \text{ in } J^A}$$

$$\frac{dy}{dt} = \left(\frac{dy}{dt}\right)_{J \text{ in } J^A} + 2\left(\frac{dh}{dt}\right)_{J \text{ in } J^A}$$

In the track laid with 30-50 kgr./m. (60.5-100.8 lb. per yard) rails, the length of the low spot, $2x_0$ in figure 2, can be assumed as 90-120 cm. (2 ft. 11 1/2 in. to 3 ft. 11 1/4 in.)

In this case the maximum dynamic augment of the load is estimated at 60 % to 115 % of the wheel load at the speed of 50-70 km. (31 to 43 1/2 miles) per hour.

The effect of the spring-borne weight can also increase this impact load to some extent.

These dynamic augments of loads are found on the track within the distance of about 100-160 cm. (3 ft. 3 3/8 in. to 5 ft. 3 in.) from the joint. The breakage of rail occurs most frequently within this distance.

Besides, the negative bending moment in the rail joint due to the dynamic augment of load as described above must be appreciable, and the upper flange of fish-plates is subjected to large tensile stress. This is one of the primary causes of the breakage of fish-plates.

On similar subjects experiments were effected by the South Manchuria Railway, on which a brief remark will be made in the following.

A single axle load of 20 metric tons (19.7 Engl. tons) was applied on the rail of a track built with test sleepers of the same kind of wood which were of exactly the same size. With such a track the elastic curve of the sleepers directly under the load was determined. Then, a few of these sleepers were removed from the track and full size tests were made in the laboratory for finding the average modulus of elasticity. Thus, the fiber stress and the bending moment to which the sleepers were subjected were found by means of graphical differentiation of the elastic curve. The following is the stresses produced in the sleepers directly under the statical single axle load of 20 metric tons on a standard track of this railway, which consisted of 50 kgr./m. rails, of 18 sleepers per 10 m. (32 ft. 9 3/4 in.), each 16 cm. × 24 cm. × 260 cm. (6 5/8 in. × 9 7/16 in. × 8 ft. 6 3/8 in.), and of ballast 30 cm. (12 inches) in depth from the bottom of the sleeper.

1. The maximum stress governing the dimensions of the sleeper was almost always produced in parts which were directly under the rail, so far as the results of the investigations are concerned.

2. The stresses to which the sleeper was subjected differed very widely from one another. It was 20 kgr./cm² to 70 kgr./cm² (284.5 to 995 lb. per sq. inch.), generally being 45 kgr./cm² (640 lb. per sq. inch).

Besides, experiments were conducted on a test track the rails of which were laid on a rail support built, not with sleepers, but with springs of uniform stiffness.

The results showed that the counterforce of the rail support directly under the 20-ton (metric) statical single axle load was about 3.2 tons per rail, and the largest counterforce to which the rail support at the joint was subject due to a train running at 40 km. (25 miles) per

hour was about 8 tons under the wheel of a 60-ton wagon with new rails 25 mm. (1 inch) in clearance between them. The same may generally be said of the heaviest locomotive. This fact indicates that the largest fiber stress in a sleeper on the standard track of this railway is about $70 \times \frac{8}{3.2} = 175$ kgr./cm² (2 500 lb./in.²).

The North Western Railway (India) calculates the rail stress by the following formulæ :

$$X_1 = 82\sqrt[4]{\frac{I}{u}} \quad \ldots\ldots \quad \text{inches,}$$

$$M_0 = 0.318\,PX_1 \quad \ldots\ldots \quad \text{inch-tons,}$$

$$y_0 = \frac{10.7\,P}{\sqrt[4]{I u^3}} \quad \ldots\ldots \quad \text{inches,}$$

$$f_0 = \frac{26.7\,P}{SM}\sqrt[4]{\frac{I}{u}} \quad \text{tons per square inch.}$$

where :

M_0 = bending moment in inch-tons immediately under an isolated load P-tons on one rail.

f_0 = consequent stress immediately under the load P, in tons per square inch.

y_0 = depression of the track in inches immediately below the load.

X_1 = distance from the load to the point of contraflexure of the rail in inches.

P = load on one rail in tons.

I = moment of inertia of rail, inch⁴.

SM = section modulus of rail, inch³.

Question 3. —*If you have or know any stress-recorders for rails and fish-plates which are reliable even with high-speed working of trains, please give us information of the details of their construction and the results of the measurement with them.*

Dr. P. H. Dudley was the originator of the stremmatograph for determining stresses in rail bases under high-speed service. Later, this stremmatograph was somewhat improved by the Special Committee on Stresses in Track of the American Railway Engineering Association. Extensive tests were carried out on tracks by this apparatus, the result of which was published in the *Proceedings of the American Railway Engineering Association* and of the *American Society of Civil Engineers*. Of the railways giving answers to this question, the following have requested us to refer to the above-mentioned *Proceedings :*

Norfolk and Western Railway;
Canadian Pacific Railway;
Chinese Government Railways;
New York Central Lines;
Pennsylvania Railroad;
Illinois Central Railroad;
Richmond, Fredericksburg and Potomac Railroad;
Wabash Railway.

The South African Railways and Harbours and the South Manchuria Railway have reported that they have experience with the use of this stremmatograph and of similar ones, but that these have to their regret proved somewhat unreliable at the high speeds due to inertia effects. The same has also been experienced by the Japanese Government Railways. After all, it may be said that though the stremmatograph is a well-known rail stress recorder, yet a satisfactory result may not be expected from it at a higher speed of train operation.

The Buenos Ayres Western Railway considers the Cambridge Instrument Co.'s stress recorder to be the most suitable for rails. But we think it may be good for railway bridges, but not for rails.

The Delaware and Hudson Railroad, Baltimore and Ohio Railroad, Pennsylvania Railroad and New York Central Lines have referred in their answers to the magnetic strain gauge recently devised by the Westinghouse Electric and Manufacturing Company, East Pitts-

burg, Pa., U. S. A. All that the New York Central Lines has said to us is that this apparatus is the most efficient and effective and that stresses in both rails and bars have been successfully recorded by it at 90 miles (145 km.) per hour and with a high degree of accuracy. The details of construction or of operation of the appartus seem not to have been well known to the four said American railways, though, it may be noted in this connection, the particulars are given in the *Proceedings of the American Society for Testing Materials*, Vol. 30 (1930).

Since this apparatus is not solely mechanical as the above-mentioned stremmatograph, we think it may, as stress recorder, be far better than the stremmatograph, though it seems somewhat inconvenient for us, because with this apparatus some sort of high-frequency power is required in field testing.

But it is a pity that we have had no experience with the use of this apparatus nor received any detailed information thereof from the American railways.

The Japanese Government Railways had for years been making great efforts for working out a stress-recorder which would be reliable even at a higher speed of train operation. Recently they succeeded in making an ingenious apparatus, which is a kind of electric telemeter. Its principle was reported at the 11th session of the International Railway Congress Association, and an outline of its construction is described below.

With this apparatus the amount of the stress (that is, the strain within a given gauge length) and of the depression of rails to be measured is read in terms of electric current which varies proportionnally to the amount of stress or depression. The slide wire method is adopted, and the record is obtained by means of a portable six-element oscillograph which has been designed for the purpose.

A chief advantage of the apparatus is that the stresses at four different points and the depressions at two different points can be recorded at the same time

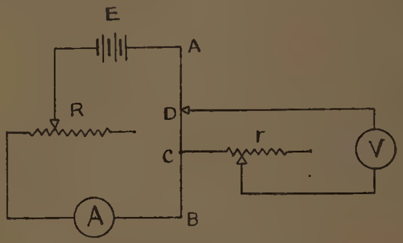


Fig. 3.

and the record can easily be magnified any times, as there is no large inertia mass of the recording part.

In figure 3, « AB » is a resistance wire and a current from a battery « E », is adjusted by a rheostat, « R ». A point, « C », is soldered on « AB », and « D » is a contact point which slides a distance in proportion to the stress or depression of the rail under the rolling load. There is some potential difference between « C » and « D » according to the amount of current flowing through the resistance wire, « AB », and to the value of resistance between « C » and « D ». The current in the shunt circuit, « DVC », therefore, will vary with the amount of the stress or the depression. Thus, we can measure the stress or depression by recording the variation of this current by means of the oscillograph at any required magnification, which is made possible by adjusting the rheostats, « R » and « r ».

Thus, the longitudinal, lateral and any other stresses in rail can be measured by applying a proper attachment which reduces different amounts of stress to proper variations of the electric current in the shunt circuit, « DVC ».

Figure 4 shows one of these attachments (the gauge length is 100 mm.

Fig. 4.

Fig. 5.

[3 15/16 inches]) intended for measuring the longitudinal stresses in both extremities of the base of the rail flange. The depression of the rail is measured on the same principle, and the attachment for this purpose is shown in figure 5.

Figure 6 shows these attachments applied to the rails.

Figure 7 shows the oscillograph de-

Fig. 6.

signed for the purpose, and it is placed in a safe position at a distance from the rail.

Figure 8 shows the wiring diagram under service conditions. Of the wirings enclosed with the thick dotted line representing the resistance box of the oscillograph, the two on the right are for the depression measurement and the four on the left for the stress measurement. The latter are more complicated than the former which correspond to the wirings in figure 3.

As the point, « C », on the resistance wire of the attachment is a soldered one, it is not a geometrical point. Figure 9 shows this point as magnified. If the sliding point, « D », were initially on the hatched part which represents the soldered metal and moved from D′ to D″, we could not express linearly the relation between the current flowing through the shunt circuit and the displacement of « D ».

To avoid this trouble, an initial position of a sliding contact point, « D », on the resistance wire is kept about 2 mm. (5/64 inch) apart from the soldered point. Moreover, as the displacement of the sliding point in the stress measurement is very small, vibrators of high sensitivity (V_1, V_2, V_3 and V_4) are

Fig. 7.

used. Thus, it becomes necessary to cancel the initial potential difference between « C » and « D » or the initial large deflection of a light spot of the vibrator. Such being the case, an auxiliary circuit with a small dry battery in it is used as shown in the diagram of figure 8.

The sensitivity of the vibrators (V_5 and V_6) is much lower in the depression measurement than in the stress measurement, so there is no necessity for such an auxiliary circuit.

Each measurement is recorded on photographic bromide paper.

Figure 10 shows one of the results observed with this apparatus. Lines (1), (2), (3) and (4) in the record give the variation of stresses [amount of the expansion and contraction within a 100-mm. (3 15/16 inches) gauge length are recorded under 104 magnifications (200 in the original photograph)] in 50-kgr. rails under the passenger train hauled by a 2-4-4-2 type electric locomotive at a speed of 72 km. (44.7 miles) per hour Lines (5) and (6) show the depression of the same rails, as magnified about 10 times (20 times in the original photograph), under the same train.

In conclusion, the measurement of stresses in rails in the track, which are produced by rolling stock is of great im-

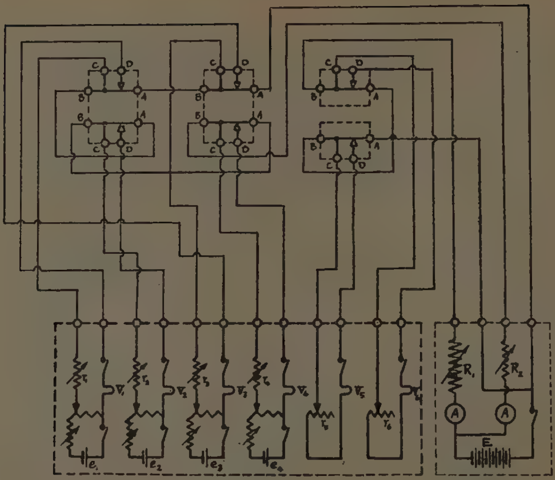


Fig. 8. — Resistance box of oscillograph.

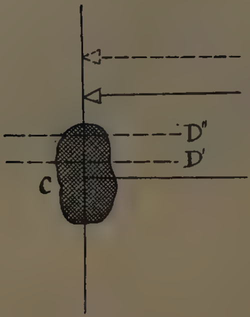


Fig. 9.

portance from the view-point of safety in high-speed train operation, and we are very glad of the invention of the magnetic strain gauge by the Westinghouse Co. and the stress recorder by the Japanese Government Railways. It is necessary to make an exhaustive study of rail stresses with such apparatus.

Question 4. — *We want to know of the use and advantages of longer rails on the section under high-speed train working.*

The maximum length of rails now used as standard on track of the reporting railways is given in table 3.

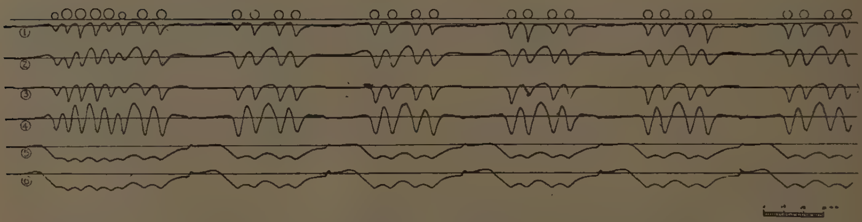


Fig. 10. — Curves for stresses and deflections of rails recorded by the Japanese Government Railways' recorder.

TABLE 3.

TRAMWAYS.	Length of rails.	
Federated Malay States Railways	40 feet	(12.192 m.)
Madras and Southern Mahratta Railway	40 —	(12.192 m.)
New Zealand Government Railways	42 —	(12.802 m.)
Sudan Government Railways	36 —	(10.973 m.)
South African Railways and Harbours	40 —	(12.192 m.)
Japanese Government Railways	39.37 feet	(12.000 m.)
Baltimore and Ohio Railroad	39 feet	(11.887 m.)
Norfolk and Western Railway	39 —	(11.887 m.)
Reading Company	39 —	(11.887 m.)
Canadian Pacific Railway	39 —	(11.887 m.)
Government Railways in Chosen	39.37 feet	(12.000 m.)
Railway Clearing House	60 feet	(18.288 m.)
Central of Georgia Railway	39 —	(11.887 m.)
New South Wales Government Railways	40 —	(12.192 m.)
Chinese Government Railways.	39.37 feet	(12.000 m.)
Kansas City Southern Railway	39 feet	(11.887 m.)
New York Central Lines	39 —	(11.887 m.)
Canadian National Railways	39 —	(11.887 m.)
South Manchuria Railway	35 —	(10.668 m.)
Pennsylvania Railroad	39 —	(11.887 m.)
Illinois Central Railroad	39 —	(11.887 m.)
Buenos Ayres Western Railway	40 —	(12.192 m.)
Buenos Ayres and Pacific Railway	41.01 feet	(12.500 m.)
North Western Railway (India)	36 feet	(10.973 m.)

Of these railways, the Reading Company (U. S. A.) uses 66-foot (20.1 m.) rails in order to reduce the number of rail joints at highway grade crossings, in station grounds and in other places where the tamping of ballast is more difficult or expensive. The Pennsylvania Railroad also makes use of longer rails for highway grade crossings. 18-m. (59 ft. 5/8 in.) rails are now experimentally laid in track at highway grade crossings of the Buenos Ayres Western Railway.

Longer rails mean a smaller number of rail joints, which are weak points of track. Investigations made by the Japanese Government Railways show that labour required for tamping ballast under rail joints is estimated at 53 % of that for tamping the whole track. Thus, the decrease of rail joints not only leads to less shock and noise in train working and to more comfortable riding of passengers, but it also facilitates the maintenance of way. Moreover, the reduction in number of sleepers, fish-plates, etc. resulting from the decrease in number of rail joints lowers the cost of permanent way construction. These are advantages of longer rails. But if rails are too long, they will naturally involve some inconveniences as regards conveyance and handling. The railways reporting to us are, therefore, almost unanimous in admitting that there should be limits to the length of rails, which are

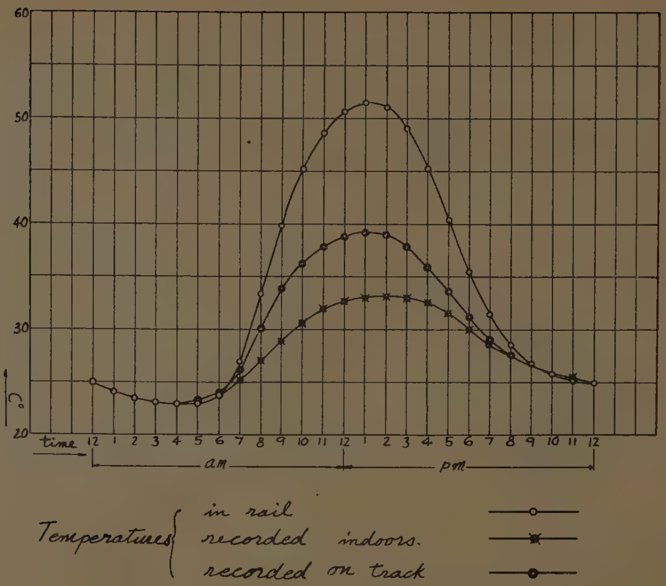


Fig. 11. — Change of temperature in rails in summer.

dependent upon local conditions. The Japanese Government Railways have for years investigated the subject and recently laid a number of 24-m. (78 ft. 9 in.) rails on a main line, while on the British Railways belonging to the Railway Clearing House, 45-foot (13.70 m.) rails have been replaced with 60-foot (18.30 m.) rails with a satisfactory result. It appears that the length of rails tends to be gradually increased with the improvement in ways of handling them.

For reference, the result of the experiment on the temperature change of rails which was carried out by the Japanese Government Railways are given in figures 11 an 12.

The experiment by the same railway has shown that the expansion due to change of temperature of rails at the joint can be avoided by the use of rail anti-creepers.

Question 5. — *If you have had experience with electric, gas or thermit welding of rail joints under high-speed train working, please let us know the procedure and results of such welding.*

It is strange that welding technique, which has of late been making rapid progress in ship-building, building construction and other industries, has somewhat been neglected by railway staff interested in track construction or maintenance. Generally speaking, there are two distinct purposes for which welding is used at the rail joint. On the one hand it is done for making repairs on battered joints and on the other for welding up rail joints, so that rails may to some extent be made jointless and may serve as longer rails.

The rail joint is generally made of fish-plates and bolts. But on account of

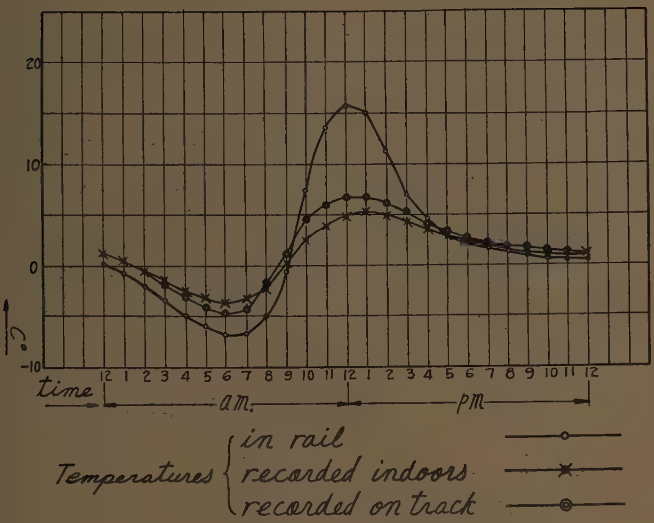


Fig. 12. — Change of temperature in rails in winter.

a clearance of some extent usually left between rails to make allowance for the expansion and contraction due to temperature changes the rail end becomes somewhat worn by the shock of the wheels and finally becomes the so-called « battered end ». Repairs thereon by welding will therefore prolong the life of rails and improve their riding condition. The same may be said of switches and frogs.

The Norfolk and Western Railway has been using the oxy-acetylene welding process for a number of years in building up battered rail ends, frog and switch points, and for other miscellaneous purposes. The Reading Company has also reported that while the oxy-acetylene method of welding was used four years ago for saving expenses in maintaining the joints to true level, the rails are still in position and the railway has not had any trouble with them.

The Canadian Pacific Railway has done considerable electric building up of battered rail ends on high-speed tracks, and is well satisfied with the results obtained.

Further, a paper entitled « Welding Instruction » (Building up rail ends in main track service under traffic by the metallic arc welding process) which has been sent to us by the same railway deals with the measures to be taken and regulations as to welding operation, and has proved very instructive to us.

On the North Western Railway (India), some little experience has been obtained in connection with the repairs of frogs by electric welding. The noses and wing rails of worn frogs have been built up in the shops and ground down to the levels required. Some of them were placed in the track a little over two years ago and are still in a serviceable condition, though wear has taken place on the wing rails and nose.

On the Japanese Government Railways

experimental repairs by arc welding were conducted on frogs which had been laid in sections with high traffic density and had been subjected to heavy wear. The welding was done by means of a manganese steel electrode with special flux. As the thermal capacity of the base metal was fairly large, the deposited metal was acted upon by an effect like water-toughening. Thus, manganese steel of austenite structure was obtained, which had a high resistance against wear.

As for the welding of rail joints, the matter of prime concern for us is the expansion and contraction of rails due to temperature change. In view of the fact that longer rails are gradually favoured, we think it desirable to weld up a number of, say, three rails and to make ordinary joints at both ends which will serve as expansion joints. By decreasing in this way undesirable rail joints the same advantages may be gained as would be by longer rails. Welding of rail joints on electrified track sections seems to be a subject of great interest, because, as stated later on in the report of the Japanese Government Railways, welded rail joints are not only of very great strength, but are of small electric resistance. Further, apart from electrified sections, difficulties in maintenance of track having ordinary rail joints at paved road crossings may easily be overcome by welded joints.

Rail joints at road crossings are made by the arc welding process on the New Zealand Government Railways. The adjoining rails are fully butt-welded and in addition the fish-plates, after being bolted on, are welded to the rail with longitudinal welds, top and bottom. The results have proved so far satisfactory after a period of 1 1/2 years.

On the Central of Georgia Railway, rail welding is done with gas. Here, the rails are butted together and V-shaped grooves are cut in the rails at the joint at both top and bottom, leaving contact between the rails about midway between head and base. Welding is then completed, angle bars applied and the rail is ready for use. Results obtained are satisfactory.

The Buenos Ayres Western Railway has made experiments with both electric and gas welding on rail joints at level crossings on the local electrified tracks.

In the electric arc process the electrode used was a covered high carbon steel. Four joints of the small V-type welded by this process, were all broken after 15 months.

In the oxy-acetylene process, the welding bar used was a pure soft Swedish iron. By this method, 123 joints were welded, 89 of the V-type and 34 of the common type; of the first mentioned, 33 were found to be broken after 48 months and 56 were found to be in good condition, after 60 months service. Of the second, or common type, 9 were found to be broken after 36 months service and 25 to be in good condition after 41 months.

The Kansas City Southern Railway has joints welded by the thermit process, in paving, with satisfactory results.

Among the railways giving answers to us, the New York Central Lines is the Company which has the widest experience with welding of rails on track. The same administration carried out electric welding in 1930 on rails in a track section some 13 miles in length. The work was done by contract, using special alloy rods with fluxing medium, and no subsequent heat treatment.

Experience with oxy-acetylene welding is spread over about 6 years and on some 125 miles of track of this railway. This was done by company forces and by contract. The welding was not successful, as a number of welds chipped and battered. Furthermore, the weld is softer than those done electrically and does not stand up as well.

The only thermit welding the New

York Central Lines have done was on the 141-lb. (70 kgr.) girder rail, where the speed has not exceeded 15 miles (24 km.) per hour. This was also contract work and the results have been very satisfactory.

The Wabash Railway has obtained a good result, where gas or electric welding was done on the rail joints at paved road crossings, the process being the same as was applied by the New Zealand Government Railways.

The Japanese Government Railways, seeing the characteristics and merits of welding up of rail joints, has for years been making a close study thereon. A few years ago, lengths of 8 and 6 rails respectively were for the first time experimentally welded up by the thermit process which showed a satisfactory result. Since then series of experiments have been made of various designs in track section of high speed and high traffic density.

The following is an example of the results of a comparative study by experiment on welded joints and ordinary ones of 50-kgr. rails of P. S. type.

TYPE OF JOINT.	Bending test (span, 1 000 mm. [3 ft. 3 3/8 in.]).		Electric resistance (μΩ) within a length of 1 000 mm.
	Load at elastic limit. (kgr.)	Ultimate load. (kgr.)	
1. Fish-plate of flat bar type, (Double rail bond).	4 500	35 200	97.7
2. Ditto, but, welding is done between rail and upper and lower parts of fish-plate.	15 000	44 500	19.3
3. Base-plate-head-bar joint	33 000	62 340	24.7
4. Thermit joint	42 000	69 130	31.9

Nos. 2 and 3 in this table were welded by the arc welding process. Their load at elastic limit was 3 to 6 times as large as that of an ordinary one, while their electric resistance wass less than 1/4 of an ordinary one. Moreover, the former joints are less expensive than the latter. The thermit process is indeed an excellent one, so far as the results of the experiment are concerned, but it is very expensive and repairs on joints welded by this process when they are affected with cracks, are rather difficult. So, the arc welding is considered as the best process for rails..

Welding of rail joints having the merits as stated in the foregoing, we think it is a subject which demands a closer study in future. Only, rail steel being high carbon one and rails being subjected to severe shock by incessant running of rolling stock, the welding technique may be attended with no small difficulties, which are to be overcome with the advancement in the theory and practice.

Question 6. — *Please give us information of the method of measuring the gauge of track and of the gauge allowance in your railway.*

The gist of the answers received from different railways is as follows :

New Zealand Government Railways. — The gauge is measured between the running edges of rails on a level 3/4 inch (19 mm.) below the top of the rails. When rails are worn or spread to more

than 1/4 inch (6.4 mm.) over the regulation slack, the curve is regulated.

Japanese Government Railways. — The gauge is measured by means of a track gauge which takes the smallest distance between rail heads at points 16 mm. (0.63 inch) or less below the plane of the top of rail heads, the allowance being as follows :

Increase	4 mm.	(0.158 inch)	for frog.
Decrease	2 mm.	(0.79 inch)	
Increase	6 mm.	(0.236 inch)	for others.
Decrease	3 mm.	(0.118 inch)	

Reading Company (U. S. A.). — The gauge is measured by the use of a standard track gauge which takes the distance between the rail heads at a point 5/8 inch (15.9 mm.) below the plane of the top of the rail head. The gauge, including widening due to wear, is not permitted to exceed 4 ft. 9 1/2 inches (1 461 mm.).

Government Railways of Chosen. — The gauge is measured by means of a track gauge, the allowance being as follows :

Increase	4 mm.	(0.158 inch)	for frog.
Decrease	2 mm.	(0.079 inch)	
Increase	6 mm.	(0.236 inch)	for straight.
Decrease	3 mm.	(0.118 inch)	
Increase	8 mm.	(0.316 inch)	for curve.
Decrease	4 mm.	(0.158 inch)	

The allowance for the straight lines applies to curves over 1 600 m. (80 chains) in radius. Further, the total of the slack or extra width and the above-mentioned increase shall not exceed 35 mm. (1.378 inches).

Central of Georgia Railway. — The gauge is measured with a standard track gauge held at right angle to the track, which makes contact at points 5/8 inch (15.9 mm.) below the top of the rails.

New South Wales Government Railways. — The gauge is measured at a point 5/8 inch (15.9 mm.) below the top of the rail head by means of an insulated track gauge.

No increase in gauge is allowed when laying new track for any curvature variation ; but rails are allowed to wear to 1/2 inch (12.7 mm.) wide of gauge before being repositioned.

Chinese Government Railways. — The gauge is measured between the inner surfaces of the top flanges of rails at points 15 mm. (0.59 inch) below the top of the rails.

The gauge allowance is 3 mm. (0.118 inch more or less in variation.

Kansas City Southern Railway. — The gauge is measured at points 5/8 inch (15.9 mm.) below the top of rail head by means of a standard track gauge.

A variation of 1/2 inch (12.7 mm.) is permissible, before regauging is required.

The entire main line also is gauged periodically by a two wheeled gauge operated as a trailer behind a motor car which indicates by a lever arrangement the gauge continuously and sounds an alarm when the gauge is over 1/2 inch (12.7 mm.) wide.

South Manchuria Railway. — The gauge is determined by measuring the smallest distance between the inside sur-

faces of rails at points 16 mm. or less below the plane of the rail head.

Until the variation in gauge due to running of trains reaches the following, correction is not necessary. But the distance between rails shall never exceed 1 470 mm. (4 ft. 9 7/8 in.)

Increase . . . . 4 mm. (0.158 inch)		for frog.
Decrease . . . . 2 mm. (0.079 inch)		
Increase . . . . 6 mm. (0.236 inch)		for straight and turnout (exclusive of frog).
Decrease . . . . 3 mm. (0.118 inch)		
Increase . . . . 10 mm. (0.394 inch)		for curve.
Decrease . . . . 3 mm. (0.118 inch)		

Pennsylvania Railroad. — The gauge is measured on a plane 5/8 inch (15.9 mm.) below the top of the rail.

It is not necessary to regauge the track on straight line, unless the excess in gauge amounts to more than 1/8 inch (3.2 mm.), nor on curves, unless it is more than 1/4 inch (6.4 mm.), provided the gauge is uniform.

Wide gauge due to curve worn rail within safe limits of wear, need not be corrected, until the excess in gauge is equal to or exceeds 1/2 inch (12.7 mm.).

Illinois Central Railroad. — Within proper limits, slight variation of gauge from the standard is not seriously objectionable, provided the variation is uniform and constant over a long distance.

In fine, the most important point is that a sudden change of track gauge at rail joints should not cause any trouble with the running of rolling stock. Moreover, for sharper curves, it appears that the subject has to be dealt with by taking into consideration the minimum width of the wheel tyre, the maximum widening of gauge, displacement of rails, etc.

Question 7. — *By what method is determined the standard of slack on the curved section under the high-speed train working in your railway? (In other words, in what way and on what basis is determined the relation between the above-mentioned standard and the rigid wheel base, radius of curves, etc.?)*

Unfortunately, we have been unable to receive answers to the point relative to this question. Most of the railways seem to be dealing with the subject on the ground, not of theory, but of years' experience. But the Burma Railways adopt the following formula for tracks run over by rolling stock with the maximum rigid wheel base of 13 ft. 5 in.

$$S = 0.82\ (\theta - 3),$$

where :

S = degree of curvature,
θ = slack in sixteenths of an inch.

Series of experiments made by the Japanese Government Railways have shown that the centre of rotation of the rigid wheel base at the time rolling stock is running through a curve is at a point about 3/4 of the wheel base from its front end. On the basis of the results of these experiments, the relation of a required slack to a rigid wheel base and a radius of curve has been determined in the following simple way :

$$\frac{3}{4} G^2 = \left(2R - \frac{S'}{1\,000}\right) \frac{S'}{1\,000} \quad \ldots \quad (1)$$

where :

G = largest rigid wheel base in metres,
R = radius of curve in metres,
S' = slack required in metres.

Since, at present, G = 4.60 m. (15 ft. 1 1/8 in.) may suffice, equation (1) can be reduced to

$$S' = \frac{5\ 951}{R} = \frac{6\ 000}{R} \quad . \ . \ . \quad (2)$$

There is, however, a play of 5 mm. (13/64 inch) between wheel gauge and track gauge on each side. It is not right that this play should remain after the track has been provided with slack. So, the following formula for the calculation of slack S has been reached :

$$S = \frac{6\ 000}{R} - 5 \quad . \ . \ . \ . \quad (3)$$

Slack S for various radii R of curves as calculated according to equation (3) are tabulated in the following :

Radius of curve	(m.)	100	200	300	400	500	600	700	800
	(*chains*)	*4.97*	*9.94*	*14.91*	*19.88*	*24.85*	*29.82*	*34.79*	*39.76*
Slack	(mm.)	55	25	15	10	7	5	4	2
	(*inches*)	*2.165*	*0.984*	*0.591*	*0.394*	*0.276*	*0.197*	*0.158*	*0.079*

It will be seen from this table that equation (3) gives a very large slack for a smaller radius of curve. The maximum slack, therefore, has been fixed at 30 mm. (1.181 inch) for providing against derailment of wheels. The relative position, at the 30-mm. slack, of the rail and the wheel the tyre of which has been worn to the permissible limit is illustrated in figure 13.

In short, it is desirable that a proper amount of slack should be given to curves less than 400 m. (19.88 chains) in radius by referring to the rigid wheel base, width of the wheel tyre, gauge allowance, etc.

Question 8. *What amount of slack is given on your railway to the curve of the turnout on the section under high speed train working ?*

The amount of slack given to lead curves of turnouts on different railways is shown in table 4.

TABLE 4.

Railways.	*Slack given to the lead curve of turnout.*
New Zealand Government Railways	1/2" (12.7 mm.).
South African Railways and Harbours	1/4" (6.4 mm.).
Japanese Government Railways .	19 mm. (0.748") for No. 10 and No. 12 turnouts. 6 mm. (0.236") for No. 16 turnouts.
Reading Company	1/2" (12.7 mm.) for No. 6 and No. 8 turnouts. 1/4" (6.4 mm.) for No. 10 turnout. No slack for the turnout flatter than No. 10.
Government Railways of Chosen.	1/4" (6.4 mm.) for No. 12 turnout. 3/16" (4.8 mm.) for No. 15 turnout.
Chinese Government Railways. .	6.5 mm. to 15 mm. (0.256" to 0.591").
South Manchuria Railway . . .	30-mm. (1.181") for No. 8 turnout. 22 mm. (0.866") for No. 9 turnout. 19 mm. (0.748") for No. 10 turnout. 15 mm. (0.591") for No. 12 turnout. 8 mm. (0.316") for No. 15 turnout.
Pennsylvania Railroad	No slack for No. 15 turnout; 1/2" (12.7 mm.) for No. 8 to No. 10 turnouts. 1" (25.4 mm.) for No. 4 to No. 7 turnouts.

There are many railways where the slack for ordinary curves is also given to turnout curves behind the frog.

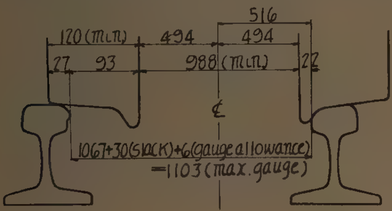


Fig. 13.

According to the foregoing, it seems to be the most common practice that slack of 12 mm. to 19 mm. (0.472 to 0.748 inch) is given to lead curves of No. 10 to No. 16 turnouts when trains are permitted to run over the turnouts at higher speed.

Question 9. — *What are the methods, on your railway, for reducing the slacks mentioned in Questions 7 and 8?*

The summary of the answers to this question is given below.

New Zealand Government Railways. — On ordinary curved track, where there is no transition curve, the gauge begins to widen out 20 feet (6.10 m.) before reaching the curve and gets the full slack 20 feet (6.10 m.) along the curve. Where there is a transition curve, the gauge begins to widen at the springing of the transition curve and gets the full slack in 40 feet (12.20 m.) along the transition curve (see fig. 14).

On turnout curves the length of run-out at each end is 10 feet (3.05 m.).

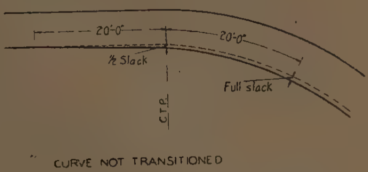
Sudan Government Railways. — The slack on curves from 1/2 inch (12.7 mm.) back to true gauge is eased off in one rail length of 30 feet (9.14 m.) or 36 feet (11 m.) according to rails used.

South African Railways and Harbours. — The widening of the gauge on curve is reduced at the end of the curve over a length of about 80 feet (24.40 m.).

On turnouts the gauge is gradually reduced from 3 ft. 6 1/4 in. (1 073 mm.) at the point of the switch to 3 ft. 6 in. (1 067 mm.) at the heel.

It is then gradually widened to 3 ft. 6 1/4 in. (1 073 mm.) on a distance of 10 feet (3.05 m.) and continued to a distance of about 17 ft. 6 in. (5 300 mm.) from the nose of the frog. It is then reduced to 3 ft. 6 in. (1 067 mm.) about 7 ft. 6 in. (2 300 mm.) from the nose and continued at this gauge to the end of the turnout.

Japanese Government Railways. — *a*) Reducing the slack on ordinary curves.



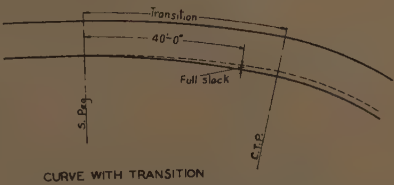


Fig. 14. — Method of reducing slack on curves (New Zealand Government Railways).

The slack is uniformly decreased to the normal gauge on the whole length of a transition curve, if there is such a curve 5 m. and over in length. In other cases, the reduction is made on a length of 5 m. (16 ft. 5 in.) from the point or the end of the circular curve. If there are compounded curves, the difference between the slacks on both curves is decreased to zero within a length of 5 m. on the curve of larger radius.

b) Reducing the slack on turnout curves.

In the case of No. 10 and No. 12 turnouts, the slack is decreased by 13 mm. (0.512 inch) within the lead curve on a length of 1.20 m. (3 ft. 11 1/4 in.) extending from the heel of the switch, and by 19 mm. (0.748 inch) on a length of 2.00 m. (3 ft. 3 3/8 in.) extending from the toe of the frog.

In the case of No. 16 turnout, the slack is decreased by 6 mm. (0.236 inch) within a length of 1.20 m. of the lead curve only on the side of the toe of the frog and full slack is given to the point of switch. The details are shown in figures 15, 16 and 17.

Canadian Pacific Railway. — The extra width of gauge is uniformly decreased on the easement curve.

No. 10 turnout.

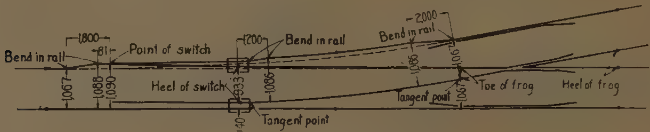


Fig. 15.

No. 12 turnout.

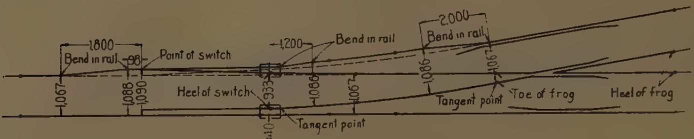


Fig. 16.

No. 16 turnout.

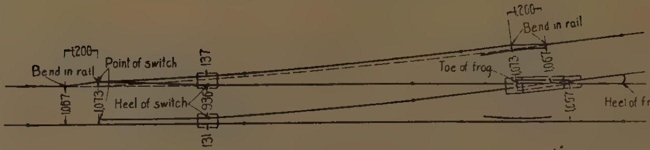


Fig. 17.

Figs. 15 to 17. — Slack on turnout curves (Japanese Government Railways).

New York Central Lines. — The extra width is uniformly decreased to standard gauge on the easement curve, and for curves not having easement, the full extra width is maintained to the end of the curve and gradually tapered off on the tangent to standard gauge within a distance of 60 feet (18.30 m.).

South Manchuria Railway. — A. Reducing the slack on curves.

a) Where there is a transition curve the slack is decreased to the standard gauge on its whole length.

b) Where there is no transition curve:

1. reduction is made on a straight line extending from the curve on a length of over 300 times the cant, if there is any cant;

2. decrease to the standard gauge is

made on a length of 10 m. (32 ft. 10 in.) and over of straight line extending from the curve, if there is no cant. If necessary, however, the decrease may be made within the curve. For instance, the difference in slack between two adjacent curves in the same direction or the difference in slack in a compound curve is decreased to zero within an intermediate straight line or on a curve of larger radius within a length of over 300 times the difference.

B. Reducing the slack on turnouts.

As for the slack on lead curve of simple and bifurcated turnouts, a full slack is given to the middle point of lead curve, and it is decreased to the standard gauge between the middle point and the heel of the switch and between the middle point and the toe of frog. As to the reduction of slack in rail part not on curves, see figures 18 and 19.

Pennsylvania Railroad. — The alignment is maintained on the outside rail

No. 12 turnout.

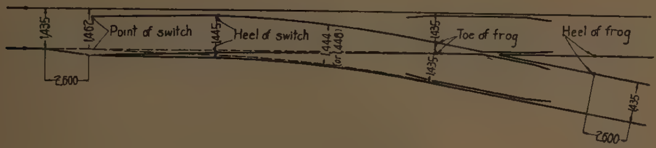


Fig. 18.

No. 15 turnout.

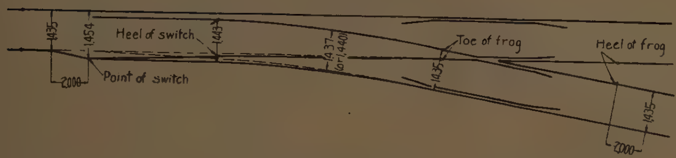


Fig. 19.

Figs. 18 and 19. — Slack on turnout curves (South Manchuria Railway).

and the extra width of gauge given by the inside rail.

The extra width of gauge is secured at the rate of 1/2 inch (12.7 mm.) to the rail length.

Where there is a transition curve, the distance from the tangent end of the transition curve to the point at which the gauge will begin to widen is found by dividing the length of the easement by the degree of curvature of the central curve and multiplying the quotient by 8. Where there is no transition curve the full extra width will extend to the ends of the curve.

North Western Railway (India). — Where transition curves are in use the slack of gauge is run out uniformly between the tangent points of the transition curve, but where there is no transition curve the slack of gauge would be run out in the same length in which the super-elevation is brought down to zero.

The reports of the various railways given above show that, when there is no transition curve, the ordinary distance for decreasing the slack is fairly large, ranging from 5 m. to 24.4 m. (16 ft 5 in. to 80 feet). On the Japanese railways the distance is specified as 5 m. (16 ft

5 in.) which is based upon the largest rigid wheel base being fixed at 4.60 m. (15 ft 1 1/8 in.). As the slack before the tangent point is reached will set up a nosing motion in the rolling stock, it is desirable that the distance for decreasing the slack should be made as small as possible. This seems to be an important point which requires careful consideration.

Question 10. — I. *In what way is the minimum radius of curves determined for the section under high-speed train working?*

II. *How do you deal with the relation between the radius of curves and the maximum allowable speed of trains on the section under high-speed train working?*

Federated Malay States Railways. — A maximum speed of 40 m. p. h. (64.4 km./h.) is permitted on curves of 6° (291 m. radius) and under. On 6° (291 m. radius) curves a cant of 3 1/4 inches (83 mm.) is given to the outer rail. This is the maximum cant permitted and the speed is reduced on sharper curves.

Burma Railways. — By the formula where:

$V = \sqrt{R - 150}$
V = maximum speed in m. p. h.
R = radius of curve in feet.

New Zealand Government Railways. — I. The maximum speed allowed on high speed sections is 50 m. p. h. (80.5 km./h.) and a curvature of not less than 20 chains (402.3 m.) radius is aimed at. Where sharper curves are unavoidable, the speed on such curves is reduced in accordance with the following table:

II. For curves of 20 chains (402.30 m.) and over, the maximum speed is 50 m. p. h. (80.50 km./h.).

For curves of 16 chains (321.90 m.) to 20 chains (402.30 m.), the maximum speed is 45 m. p. h. (72.40 km./h.).

For curves of 13 chains (261.50 m.) to 15 chains (301.80 m.), the maximum speed is 40 m. p. h. (64.40 km./h.).

For curves of 11 chains (221.30 m.), to 12 chains (241.40 m.), the maximum speed is 35 m. p. h. (56.30 km./h.).

For curves of 9 chains (181.10 m.) to 10 chains (201.10 m.), the maximum speed is 30 m. p. h. (48.30 km./h.).

For curves under 9 chains (181.10 m.) radius the maximum speed is 25 m. p. h. (40.20 km./h.).

This gives a value of maximum speed varying from 10 $\sqrt{R}$ on curves of 9 chains radius to 11 $\sqrt{R}$ on 20-chain curves.

South African Railways and Harbours. — I. The minimum radius fixed for main lines is 500 ft. (152.40 m.) and is decided mainly on economic grounds. Each case is dealt with on its own merits and the minimum curvature for each section determined. In no case must the radius be less than 500 feet (152.40 m.) on the new main lines.

II. Figure 20 shows the maximum speeds permitted on main lines and the points and crossings for various curvatures.

Japanese Government Railways. — I. The minimum radius of curve in track sections of main lines under the high-speed train working is specified as under:

a) 300 *m.* (14.91 chains) on ordinary lines; 400 m. (19.88 chains) on important lines.

b) 160 m. (7.953 chains) on curves of turnouts.

The above-mentioned limits are based upon the results of years' investigations. Further, the radius limits given above for turnouts have been decided by taking into consideration the fact that the radius of the lead curve at the existing No. 10 simple turnout of the standard design is about 160 m. (7.953 chains).

II. The relation between the radius of curve and the maximum allowable speed

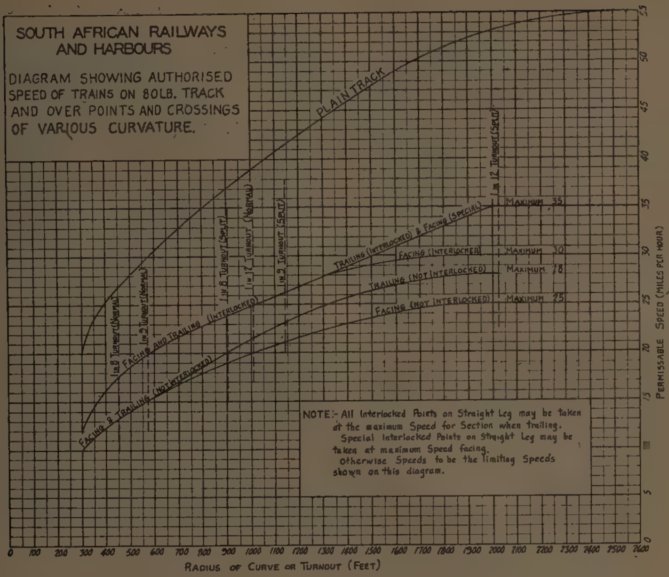


Fig. 20.

of trains should be governed by the conditions of track, types and construction of rolling stock, etc. The following is specified on the basis of the results of the investigations as to this subject :

Radius of curves (m.) (*chains*).	Maximum allowable speed (km. [*miles*] p. h.)	
	On curves not of turnout.	On curves of turnout.
600 (*29.82*)	85 (*52.8*)	65 (*40.4*)
500 (*24.85*)	80 (*49.7*)	60 (*37.3*)
400 (*19.88*)	70 (*43.5*)	50 (*31.0*)
300 (*14.91*)	60 (*37.3*)	50 (*31.0*)
200 (*9.94*)	50 (*31.0*)	45 (*28.0*)
100 m. and under	30 (*18.65*)	25 (*15.5*)

Delaware and Hudson Railroad. — I. By rule, maximum of 3° (582 m. radius).

II. The A. R. E. A. super-elevation table is used for speed and curves. A maximum of 6 inches (152 mm.) super-elevation is adhered to. At curves where degree of curve is such that this super-elevation should be exceeded, speed restriction is made.

Norfolk and Western Railway. — I. High speed track on this railroad consists of tangents and curves up to 3° (582 m. radius). In most cases, however, high speed on curves slightly in excess of 3° (582 m. radius), where the movement of freight trains is fast enough to permit a greater super-elevation of outer rails, is permitted.

II. The curves on this railroad are provided with a super-elevation to suit

the speed of trains in each locality. In localities where the speed of tonnage trains is restricted by grades or other permanent causes, the super-elevation shall be made to suit the local conditions and the speed of other trains shall be restricted to suit the super-elevation provided in such localities.

Reading Company. — I. In open, flat, high-speed territory such as the New York Branch and the Atlantic City Railroad, the curves are rarely more than 1° (1 746 m. radius). Ordinarily, in modern day construction, sharp curvature is avoided as much as possible and many lines are now constructed with a maximum of 3° curvature (582 m. radius).

II. When the super-elevation called for by safe running can not be given to the outer rail due to sharp curvature, the speed of trains is reduced.

Government Railways of Chosen. — The standard maximum speed of trains is specified as not over 90 km. (56 miles) per hour for the straight and not over 80 km. (49.7 miles) for a curve, and the cant as not more than 150 mm. (6 inches). So, in accordance with the formula for cant, $C = \frac{8.7 V^2}{R}$ (see Question 12), the minimum radius of curve is determined as 400 m. (19.88 chains).

British Railways (Railway Clearing House). — The minimum radius of curves on high speed lines is usually fixed at 40 chains (804.70 m.) and when circumstances necessitate the adoption of a curve on such lines of smaller radius, the speed is restricted.

New South Wales Government Railways. — Maximum speed allowable on curves is $1.1\sqrt{R}$ m. p. h., where R = radius of curve in feet. Limiting speed not to exceed 50 m. p. h. (80.5 km./h.). This is a safe maximum speed, but after trial, the following speeds were adopted :

Radius of curve.	*Speed limit.*
8 chains (160.90 m.).	16 miles (25.7 km.) per hour.
10 chains (201.10 m.).	20 miles (32.2 km.) per hour.
11 chains (221.30 m.).	22 miles (35.4 km.) per hour.
12 chains (241.40 m.).	25 miles (40.2 km.) per hour.
14 chains (281.60 m.).	28 miles (45.1 km.) per hour.
15 chains (301.80 m.).	30 miles (48.3 km.) per hour.
20 chains (402.30 m.).	40 miles (64.4 km.) per hour.
25 chains (502.90 m.) and over.	50 miles (80.5 km.) per hour.

Kansas City Southern Railway. — I. Speed restrictions are necessary on all curves with radii less than 437 m. (4° curves), and rail wear is rapid on curves with radii less than 582 m. (3° curves). In any location of line it is the policy to keep the radius over 582 m. (3° curves) and preferably over 873 m. (2° curves).

II. The train speed on curves is restricted so that theoretical balanced super-elevation of the curve at the maximum speed will not exceed the actual cant by more than 3 inches (76 mm.)

South Manchuria Railway. — I. The minimum radius of curve is 600 m. (29.82 chains) on the Dairen-Chang-Chun line and 400 m. (19.88 chains) on the Antung-Mukden line. As the Dairen-Chang-Chun line is built in flat districts, a minimum radius of 600 m. can easily be kept. Besides, curves of 600 m. and over in radius give remarkably improved riding conditions. For these reasons 600 m. has been specified as the minimum.

II. The formula for cant adopted by

this railway is $C = \frac{8V^2}{R}$, the maximum cant being 150 mm. (6 inches). The allowable variation of cant due to train working is ± 25 mm. (1 inch). On this basis the maximum permissible speed of trains has been fixed, so that the safety factor against overturning may be about 10 for the above standard cant and about 7 for a cant 25 mm. below the standard (See fig. 21). But it seems that a little smaller safety factor is more desirable from the view-point of reducing rail wear.

Pennsylvania Railroad. — Minimum radius of curves for high speed trains is determined by the maximum elevation of outer rail considered desirable for safe and satisfactory train operation.

Illinois Central Railroad. — The minimum radius of the curve depends entirely upon the rate of speed. On main line track the maximum curvature is

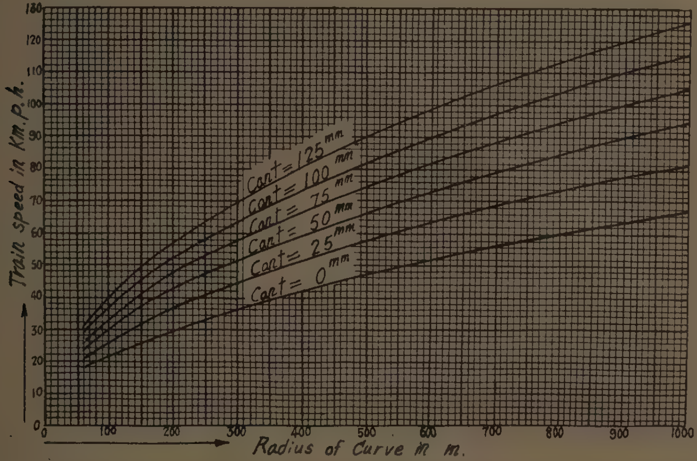


Fig. 21. — Maximum permissible speeds for various cants on curves (South Manchuria Railway).

usually 4° (437 m. radius) except in some particular cases due to the topography of the country.

North Western Railway (India). — Past experience over a number of years on this railway indicates that the maximum safe speeds over curves should be determined from the formula $V = \frac{11}{8}\sqrt{R}$ which corresponds to a centrifugal force of 1/12 of the weight; where V is in m. p. h. and R is the radius of the curve in feet.

While the permissible speed of trains on curves should be dependent upon the curvature, track gauge and construction of rolling stock, the reports quoted above show that there is generally no need of setting special limits to the speed of trains on curves flatter than 600 m. (29.82 chains) in radius.

Question 11. — *We want to be inform-*

ed of rules or regulations for reverse and compound curves on the section under high-speed train working.

The answers to this question are summarized as under :

Federated Malay States Railways. — Transition curves are introduced between reverse curves wherever possible, failing that, a length of straight is introduced. In compound curves the superelevation adopted is that deduced for the curve of greater radius.

Burma Railways. — *Straight between* reverse curves is made equal to the length of the longest bogie coaches.

The Madras and Southern Mahratta Railway. — Sufficient distance between tangents to enable transition curves to be laid.

New Zealand Government Railways. — As regards speed, no special provision is made for reverse or compound curves that are properly transitioned. As regards cant, when there is insufficient straight between two curves in opposite directions to give half the cant run-off for each curve on the straight, the track is level midway between the two curves and the run-off for each cant commences at this point. When two curves in the same direction but of different radii join, the difference in cant is run off on the flatter curve at the standard rate, except where there is a transition curve, when the run-off is on the transition curve.

Japanese Government Railways. — On reverse curves on the main line, a straight line 10 m. (32 ft. 10 in.) or over in length is introduced between transition curves. Where curves in the same direction, but of different radii are connected, a transition curve is not introduced in most cases, as the connecting length. In such cases, the difference between the cants and that between the slacks of two curves are to be decreased to zero on the curve of larger radius on a length over 300 times the cant and on a length over 5 m. (16 ft. 5 in.) respectively.

Delaware and Hudson Railroad. — On reverse curves there shall be 200 ft. (61 m.) of tangent or enough space for easement between curves.

Curves are compounded only where it is impossible to obtain a simple curve. When compounded, curves should be eased off with spiral between same.

Baltimore and Ohio Railroad. — On reverse curves, there must be a tangent of not less than 50 ft. (15.20 m.) between points of reversal.

On compound curves, any difference of curvature of 2° or more requires a transition spiral between the curves.

Reading Company. — When it is impossible to avoid the reverse curves it is always tried to put in as much tangent track between the two curves as possible.

Regarding super-elevation on reverse curves the distances of 30 ft. (9.10 m.) each side of the mid point of P. R. C. should be made flat and beyond this the outer rail is elevated to normal superelevation at a rate of 1/2 inch (12.7 mm.) to 33 ft. (10.10 m.). If, however, one or both curves are too short to do this and it is not possible to get proper superelevation, train speeds must be reduced to enable the available elevation to make the movement over the reverse curves entirely safe and reasonably comfortable. In the case of compound curves, the additional super-elevation for the second curve is divised up between the two curves.

Government Railways of Chosen. — A straight length of 50 m. (164 feet) exclusive of the length of transition curves and that of the parts where cant is decreased, is introduced between reverse curves.

British Railways (Railway Clearing House. — Reverse curves must, where practicable, have sufficient distance between them to enable the full transition curves to be provided and a length of at least 45 feet (13.70 m.) of straight between the ends of these.

Where the difference in radii of compound curves is appreciable a transition curve is provided between them.

Central of Georgia Railway. — Reverse curves are not permitted if they can be avoided in any reasonable way. Where compound curves are used with the degree of curvature varying more than 2° the curves are connected by means of transition curves.

New South Wales Government Railways. — A transition curve may reverse without any straight where room is limited. The length of transition is 4 chains (80.50 m.). There are no rules and regulations for compounded curves on steam tracks. On the Metropolitan Electric Railways, a curve may be directly compounded with another or with a tangent, provided the difference of curvature « c » does not exceed 0.00076. If « c » be greater than 0.00076, a cubic parabolic transition shall be used, the minimum length of which shall be c × 85 000 feet, curvature « c » to be measured by the reciprocal of the radius in feet.

Chinese Government Railways. — The minimum length of tangents is 100 m. (328 feet) between curves in the same direction, and 50 m. (164 feet) between curves in opposite direction. These minimum lengths are to be provided exclusive of the length necessary to run out super-elevations.

Kansas City Southern Railway. — Where reverse curves are used, a short tangent separates them. Compound curves have easement curves at the point of compound wherever it is practicable to put them.

New York Central Lines. — Where the radius at the point of compound curves varies in degree more than 1° 30′, an easement is made.

Canadian National Railways. — Reverse and compound curves are not used on high speed lines where it is possible to avoid them by inserting several hundred feet of tangent between the curves. Where it is necessary to construct compound curves, a transition curve is put between the two true curves when the difference between the curves exceeds 2°.

South Manchuria Railway. — I. The minimum straight length and a standard one at the point of reversal on reverse curves of a main line outside the station yard are 30 m. and 50 m. (98 ft. 1 5/8 in. and 164 feet) respectively, exclusive of the length of transition curves and of that on which the cant is decreased.

II. The difference in slack and in cant between two adjacent curves in the same direction is decreased to zero on a length over 300 times the difference on the intermediate straight line, and on the curve of larger radius, if necessary.

III. In case of a compound curve, no transition curve is introduced as the connecting length between the two curves. The difference in cant is decreased on a length over 300 times the difference on the curve with lower cant, but such a decrease shall not intrude into the transition curve.

Illinois Central Railroad. — On reverse curves the track must be made level at points of reverse, and full elevation obtained each way by raising the outer rail at the rate of 1/2 inch (12.7 mm.) for each 33 ft. (10.10 m.) of distance.

Buenos Ayres Western Railways. — In all reverse curves we interpolate a tangent of at least 80 m. (262 ft. 5 in.) between the curves.

TABLE 5.

RAILWAYS.	Gauge, in mm.	Formula.		Maximum cant allowed in mm.
Federated Malay States Railways.	1 000	$c = 0.00045\ DV^2$ for curves up to 3° (582 m. radius). $c = 0.0003\ DV^2$ for curves sharper than 3° (582 m. radius).	c in inches. V in m. p. h.	...
Burma Railways	1 000	$c = 0.0005\ DV^2$	c in inches. V in m. p. h.	76.2
New Zealand Government Railways.	1 067	$c = \frac{17}{400} \frac{V^2}{R}$	in inches. R in chains. V in m. p. h.	101.6
Sudan Government Railways	1 067	$C = \frac{G\,v^2}{32.2\ R}$	C in feet. R in feet. v in feet p. s. G in feet.	...
Japanese Government Railways	1 067	$c = \frac{G\,V^2}{0.127\ R}$	c in mm. R in m. V in km. p. h. G in m.	115.0
Delaware and Hudson Railroad	1 435	$c = 0.00066\ DV^2$	c in inches. V in m. p. h.	152.4
Baltimore and Ohio Railroad	1 435	$c = 0.00069\ DV^2$	c in inches. V in m. p. h.	...
Reading Company	1 435	$C = \frac{v^2}{8\ R}$	C in feet. R in feet. v in feet p. s.	...
Government Railways of Chosen	1 435	$c = \frac{8.7\ V^2}{R}$	c in mm. R in m. V in km. p. h.	150.0
British Railways (Railway Clearing House).	1 435	$c = \frac{G\,V^2}{1.25\ R}$	c in inches. R in feet. V in m. p. h. G in feet.	152.4

New South Wales Government Railways.		R	V in m. p. h.	
Chinese Government Railways .	1 435	$c = 0.009864\ DV^2$	c in mm. D in degrees (20 m. chord). V in km. p. h.	125.0
Kansas City Southern Railway	1 435	$c = 0.00069\ DV^2$	c in inches. V in m. p. h.	152.4
New York Central Lines. . .	1 435	$C = \dfrac{G\ v^2}{32.16\ R}$	C in feet. R in feet. v in feet p. s. G in feet.	...
Canadian National Railways .	1 435	$c = 0.00066\ DV^2$	c in inches. V in m. p. h.	...
South Manchuria Railway . .	1 435	$c = \dfrac{8\ V^2}{R}$	c in mm. R in m. V in km. p. h.	150.0
Pennsylvania Railroad . . .	1 435	$C = \dfrac{G\ v^2}{32.2\ R}$ or $c = 0.0007\ DV^2$	C in feet. c in inches. V in m. p. h. v in feet p. s. R in feet. G in feet.	177.8
Illinois Central Railroad . .	1 435	$c = 0.00066\ DV^2$	c in inches. V in m. p. h.	152.4
Wabash Railway	1 435	$c = 0.00066\ DV^2$	c in inches. V in m. p. h.	...
Richmond, Fredericksburg and Potomac Railroad.	1 435	$c = 0.00066\ DV^2$	c in inches. V in m. p. h.	...
Buenos Ayres Western Railway	1 676	$c = 1.360\ \dfrac{V^2}{R}$	c in cm. R in m. V in km. p. h.	...
Buenos Ayres and Pacific Railway.	1 676	$c = \dfrac{2.39\ G\ V^2}{R}$	c in mm. R in m. V in km. p. h. G in feet.	...
North Western Railway (India)	1 676	$c = \dfrac{G\ V^2}{1.25\ R}$	c in inches. R in feet. V in m. p. h. G in feet.	139.7

Note : C and c = cant of outer rail. V and v = train speed. G = Gauge to centre of rails. R = Radius of curve.

According to the answers to us, the necessity of inserting a straight between the branches of a reverse curve is generally admitted, but its length is widely varied, ranging from 10 m. to 80 m. (32 ft. 9 in. to 262 ft. 5 in.). Naturally, the longer the straight is, the better it is. But we think that, as a rule, the straight should be long enough to kill the rotary inertia of rolling stock running through the curve. The subject requires a further study.

Question 12. — *Please inform us of the formula for determining the cant on curves on the section under high-speed train working, and how and why the term of the train speed in such a formula has been used by your railway.*

The formulæ for calculating cant are equilibrium formulæ, so far as the reporting railways are concerned, in which centrifugal force alone is taken into account.

There are two forms of the formulæ.

a) $C = m\ D\ V^2$,

wherein C = cant of outer rail,
D = degree of curvature,
V = train speed,
m = constant.

b) $C = n\dfrac{V^2}{R}$,

wherein C = cant of outer rail,
R = radius of curve,
V = train speed,
n = constant.

The formulæ are given in table 5.

For facilitating a comparative study of these formulæ, let us change the form, $C = mDV^2$, into that where the cant is expressed in millimetres and the train speed in km. p. h., with the standard gauge of 1.435 mm. and the form, $C = n\dfrac{V^2}{R}$, into that where the cant is expressed in millimetres the gauge and radius of curve in metres and the train speed in km. p. h. in the form of $C = n'\dfrac{GV^2}{R}$ (where n' is constant and G is the gauge of track), then we have table 6.

TABLE 6.

RAILWAYS.	*Formula.*
Federated Malay States Railways	$C = 0.00422\ DV^2$ for curves sharper than 3° (582 m. radius). $C = 0.00637\ DV^2$ for curves up to 3° (582 m. radius).
Delaware and Hudson Railroad	$C = 0.00647\ DV^2$.
Central of Georgia Railway	$C = 0.00647\ DV^2$.
Canadian National Railways	$C = 0.00647\ DV^2$.
Illinois Central Railroad	$C = 0.00647\ DV^2$.
Wabash Railway	$C = 0.00647\ DV^2$.
Richmond, Fredericksburg and Potomac Railroad	$C = 0.00647\ DV^2$.
Chinese Government Railways	$C = 0.00657\ DV^2$.
Baltimore and Ohio Railroad	$C = 0.00677\ DV^2$.
Kansas City Southern Railway	$C = 0.00677\ DV^2$.
Pennsylvania Railroad	$C = 0.00686\ DV^2$.

TABLE 6. (*Continued.*)

RAILWAYS.	Formula.
Burma Railways	$C = 0.00706\ DV^2$.
New South Wales Government Railways	$C = 8.3 \dfrac{GV^2}{R}$.
Buenos Ayres Western Railway	$C = 8.1 \dfrac{GV^2}{R}$.
New Zealand Government Railways	$C = 7.9 \dfrac{GV^2}{R}$.
Sudan Government Railways	$C = 7.9 \dfrac{GV^2}{R}$.
Japanese Government Railways	$C = 7.9 \dfrac{GV^2}{R}$.
New York Central Lines	$C = 7.9 \dfrac{GV^2}{R}$.
British Railways (Railway Clearing House)	$C = 7.9 \dfrac{GV^2}{R}$.
Pennsylvania Railroad	$C = 7.9 \dfrac{GV^2}{R}$.
Buenos Ayres and Pacific Railway	$C = 7.9 \dfrac{GV^2}{R}$.
North Western Railway (India)	$C = 7.9 \dfrac{GV^2}{R}$.
Reading Company	$C = 6.7 \dfrac{GV^2}{R}$.
Government Railways in Chosen	$C = 6.1 \dfrac{GV^2}{R}$.
South Manchuria Railway	$C = 5.6 \dfrac{GV^2}{R}$.

Of these, $C = 0.00647\ DV^2$ and $C = \dfrac{7.9\ GV^2}{R}$ ($G = 1\,435$ mm.) give almost equal cant to curves of the same curvature and are so deduced that the resultant force of the centrifugal force acting upon rolling stock and of the weight of rolling stock running through a curve

is brought exactly to the centre of the track. Generally, such an equilibrium formula gives too high a cant to a train running through sharp curves at a lower speed, if calculation is made on the basis of the maximum speed of a train running through curves. Consequently, there are a number of railways where some allowance is made for the theoretical value obtained, or some modification is made to the formula for cant, according to local conditions, such as the number of tracks on the same line, gradients, traffic, etc.

The Japanese Government Railways apply as the basis of the train speed V in a cant formula the following equation :

$$V = \sqrt{\frac{V_A N_A + V_B N_B + V_C N_C \ldots + V_N N_N}{N_A + N_B + N_C + \ldots + N_N}}$$

where :

V_A, V_B, $V_C \ldots V_N$ = mean speed of trains of various kinds (km. p. h.).

N_A, N_B, $N_C \ldots N_N$ = number of trains running at the speeds V_A, V_B, $V_C \ldots V_N$, respectively.

Further, the following limit is put from fear any train overturning should take place on account of the cant being too low :

$$\frac{V_1^2 - V^2}{127\,R} \times \frac{H}{g} \leqslant \frac{1}{8}$$

where :

V_1 = highest train speed, km. p. h.
H = distance in metres from the centre of gravity of rolling stock to the rail surface.

In this connection, it must be noted that cant is to be given on the basis of the comparative importance of trains running over it, though it may sometimes be unfavourable for track maintenance.

Question 13. — *Is any cant given to turnouts on the section under the high-speed train working in your railway? If so, please let us know its merits.*

This question may be considered from the following three points of view :

1. Cant to be given to a turnout curve in front of a frog which branches off a straight line.

2. Cant to be given to a turnout curve in front of a frog which branches off a curved line.

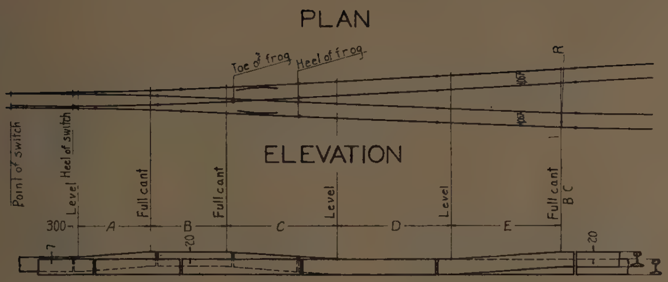
3. Cant to be given to a turnout curve behind a frog.

There are many railways where there is no cant given in (1). This seems to be on account of considerable difficulties which would be entailed by making such a cant. Only, on the Japanese Government Railways a 20-mm. (0.787 inch) cant was experimentally given with special tie-plates to outer rails on a lead curve of bifurcated No. 10 and No. 12 turnouts (see fig. 22), in a section of the main line run over by high-speed trains. The result has shown that the radius of a lead curve for bifurcated turnouts of No. 10 and above is large and accordingly cant can somewhat easily be given thereto. Moreover, vibration of rolling stock when passing over a turnout with cant has been found far less than that over a turnout without cant. But this is only a latest practice, and further investigations should be carried out as to the construction of the turnout and the amount of cant to be given.

In the case of a track branching from inside the curve, the cant in (2) is made of the same amount as that which would be given to the curve without turnout. Further, it is a general practice to give no cant to two curves when a track branches outwards off a curved line.

The cant in (3) is dealt with in the same way as that on ordinary curves.

In conclusion, we may say that it is desirable to give a proper amount of



Frog No.	A	B	C	D	E	R
No. 10	5,200	5,500	8,000	8,329	8,000	300,000
No. 12	5,200	8,000	8,000	10,000	8,000	500,000

Fig. 22. — Cant on turnout curve (Japanese Government Railways).

cant to turnout curves at station yards; where trains pass through at a fairly high speed, though it may involve extra cost for the construction of the turnout.

Question 14. — *What methods are adopted by your railway for reducing the above-mentioned two cants ?*

The gist of the answers to this question is given below :

Madras and Southern Mahratta Railway. — The cant is reduced at the rate of 1 inch in 60 feet (25.4 mm. in 18.30 m.), that is, 1 in 720.

New Zealand Government Railways. — For the reduction of cant on high-speed lines a run-off of 1 inch in 40 feet (25.4 mm. in 12.20 m.) is adopted for curves of 12 chains (241.40 m.) radius and under.

For flatter curves a run-off of 1 inch in 50 feet (25.4 mm. in 15.2 m.) is used. In special cases where a quick run-off is required, 1 inch in 30 feet (25.4 mm. in 19.10 m.) is permitted. On a transition curve the cant is reduced on the transition. Where there is no transition, half the cant is run off on the straight and half on the curve.

South African Railways and Harbours. — The cant on curves which are not transitioned is run out at the rate of 1 inch in 40 feet (25.4 mm. in 12.2 m.) from the end of the curve. On curves which are transitioned the cant is run out over the length of the transition.

Japanese Government Railways. —

I. Reduction of cant on ordinary curves :

On a curve with a transition curve the cant is decreased on the whole length of the transition curve. The length of the transition curve in sections run over by high-speed trains is over 600 times a required cant, so the rate of the decrease in cant is below 1/600. The cant on a curve with no transition curve is uniformly decreased on the straight line beyond the tangent points of the curve on the basis of the above. As when curves in the same direction, but of different radii are connected, no transition curve is generally introduced at the connecting point, the difference of cant is decreased within a length over 300 times the difference on the curve having larger radius, for securing safety for high-speed train working.

II. Reduction of cant on turnouts.

On a bifurcated No. 10 turnout, the length between the heel of switch and the heel of frog is divided into three sections or so, and a full cant is given to a length of 5.50 m. (18 ft. 9/16 in.) at the middle, which is uniformly decreased within the lengths of 5.20 m. and 8 m. (17 ft. 1 in. and 26 ft. 3 in.) at both ends. The same applies to the case of a bifurcated No. 12 turnout, only the length at the middle is 8.20 m. and those at both ends 5.20 m. and 8 m. (see fig. 22).

Chinese Government Railways. — The super-elevation on curves is levelled off on the tangents by a grade equal to $\frac{17}{V}$ %, where V = maximum train speed in km. p. h.

New York Central Lines. — For simple curves carrying the cant of 3 inches (76 mm.) and under, the rate of the run-off on the tangents is 1/4 inch per 30 feet (6.4 mm. per 9.10 m.).

For cant over 3 inches (76 mm.) the run-off is not to exceed 360 feet (109.70 m.). For compound curves, the change in cant is distributed one-half on each part of the curve.

South Manchuria Railway. — The cant on a curve with a transition curve is decreased on the whole length of the latter curve, while that on a curve with no transition curve is uniformly decreased over a length more than 300 times the cant on a straight extending therefrom. But if necessary, the cant is decreased partially on the curve.

Pennsylvania Railroad. — Where a spiral is not used the cant of outer rail is run out on the tangent at a rate not exceeding 1/2 inch per 33 ft. (12.7 mm. per 10.10 m.) rail length. Where practicable, main-track curves carrying 2 inches (50.8 mm.) or more cant are provided with easement curves of such length as will give a rate of change in cant not exceeding 1/2 inch per 33 ft. (12.7 mm. per 10.10 m.) rail length. On compound curves where the difference in cant of branches is 2 inches (50.8 mm.) or more, the branches of the compound curve are connected by an easement curve, giving a rate of change in cant of not exceeding 1/2 inch per 33 ft. (12.7 mm. per 10.10 m.) rail length.

North Western Railway (India). — Where transition curves have not been laid out, the cant is run off on the straight at the rate of 1 inch in 60 feet (25.4 mm. in 18.3 m.). Where transition curves are used, the cant is run off uniformly on the transition curve.

It goes without saying that the longer the distance is, on which the cant is reduced to zero, the better it is. At the same time it must be noted that careful considerations have to be given to the stiffness of the bearing springs of the rolling stock, to the length of the rigid wheel base, the height of the wheel flanges, the effect of resonance of vibration of the rolling stock, etc.

Question 15. — *We want to know the rules or regulations for the length, the form and method of laying of transition curves on the section under high-speed train working of your railway.*

With the remarkable increase in speed of trains, it is specified by most of the railways that for ensuring smooth running simple circular curves be connected with the tangents and with branches of compound curves by means of transitions. The forms and lengths of such transition curves now obtaining on various railways are shown in table 7.

According to this table, there are in general two types of transition curves now adopted by the reporting railways, one being the cubic parabola and the other the spiral.

The former is the better theoretically, but its setting out is troublesome, while the latter, being easier of setting out, is

more favourable for practice, so far as the curvature is made flat enough at the beginning point of the curve.

A method has been developed by the Japanese Government Railways of laying a transition curve of the cubic parabola type, with the original circular curve and tangent as datum. With this method the setting out of the curve becomes easy.

Question 16. — *Please inform us of the standard designs of turnouts and crossings on the section under high-speed train working.*

Standard turnouts now in use in sections under high-speed working on various railways are generally split switches with fixed frogs. Though the frog number is different with various conditions, such as localities where frogs are laid, speed of trains, etc., it is generally No. 10 to No. 20 for standard gauge railways and No. 9 to No. 16 for narrow gauge lines.

Most railways adopt straight point rails, their maximum length being generally 9 m. (29 ft. 6 3/8 in.) for standard gauge railways and 6 m. (19 ft. 8 1/4 in.) for narrow gauge lines.

There are three different ways adopted for preventing rolling stock from intruding into a wrong line at the point of switch.

a) The stock rail is bent at a pretty

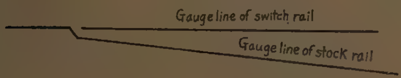


Fig. 23.

sharp angle at the point of switch to protect the extremity of the point rail and at the same time to make the gauge line as straight as possible (see fig. 23);

b) The stock rail is gently bent in front of, and at some distance, from the point of switch and at the same time the gauge side edge of the point rail is bent outwards at its extremity (see fig. 24);

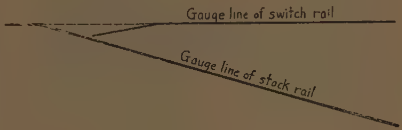


Fig. 24.

c) The stock rail is bent in front of the point of switch as in *b*), but the gauge side edge of the point rail is made straight and its extremity is protected by a rail (see fig. 25, *a* and *b*).

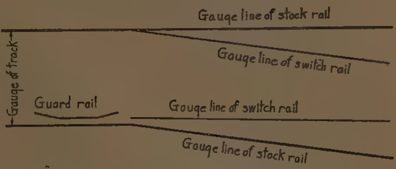


Fig. 25*a* (Japanese Government Railways).

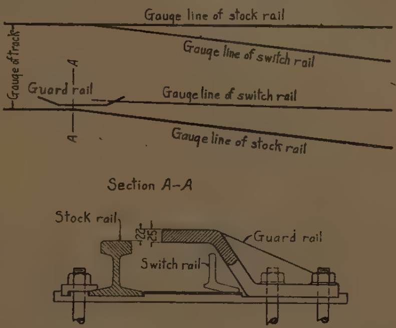


Fig. 25*b* (Japanese Government Railways).

In the *a*) type, the stock rail is liable to break at the bending point, and there is a high probability of preventing close contact between point rail and stock rail when the former rail creeps or expands due to temperature. Therefore, this type is employed on very few railways, the *b*) and *c*) types being generally favoured.

TABLE 7.

RAILWAYS.	Type of transition curve.	Length of transition curve.	Remarks.
Federated Malay States Railways.	Cubic parabola type.	Up to 200 ft. (61 m.) run-off of the cant 1 inch in 60 ft. (25.4 mm. in 18.30 m.)	...
Burma Railways	Cubic parabola type.	...	...
New Zealand Government Railways.	Cubic parabola type.	Run-off of the cant 1 inch (25.4 mm.) in S ft., where S is the speed in m. p. h.	The cant is run off entirely on the transition. Where curves of different radii occur close together, the transitions for the group of curves are designed to suit the speed of trains over the sharpest curve in the group.
Sudan Government Railways	...	For 2° curves (873 m. radius), 120 ft. (36.60 m.). For 3° curves (582 m. radius), 180 ft. (54.90 m.). For 4° curves (437 m. radius), 240 ft. (73.20 m.).	Transition curves used in all new works on curves of 2° (873 m. radius) and over.
South African Railways and Harbours.	Cubic parabola type.	...	...
Japanese Government Railways	Cubic parabola type.	600 times the cant.	Cant is decreased on the whole length of a transition curve.
Delaware and Hudson Railroad	Talbot spiral type.	...	...
Baltimore and Ohio Railroad.	Talbot spiral type.	...	...
Norfolk and Western Railway.	Searles spiral type.	...	...
Reading Company	Ten-chord spiral.	...	...
Canadian Pacific Railway	Talbot spiral type.	100 ft. (30.50 m.) multiplied by degrees of the circular curve to be spiralled, being not greater than 400 ft. (121.90 m.) or not less than 100 ft. (30.50 m.).	...
Government Railways of Chosen	Cubic parabola type.	800 times the cant for the maximum speed on a curve. In special cases 600 times the cant.	A transition curve shall be introduced between a circular curve less than 1 200 m. in radius and a straight. The minimum length of a circular curve to be left between transition curves shall be 30 m. (98 ft. 3 in.).
British Railways (Railway Clearing House).	Cubic parabola type.	Run-off of the cant 1 inch in 45 ft. (25.4 mm. in 13.70 m.). 1 inch in 66 ft. (25.4 mm. in	...

New South Wales Government Railways.	On all main lines other than Metropolitan Electric Railway, for curves, of 12 to 40 chains (241.4 to 402.3 m.) radius, cubic parabola type.	On all main lines other than Metropolitan Electric Railway, the length of transition curve, 264 ft. (80.50 m.).	On the Metropolitan Electric Railways a curve may be compounded directly with another or with tangent, provided the difference of curvature « C » does not exceed 0.00076, curvature being measured by the reciprocal of the radius in feet. Where « C » is greater than 0.00076, a cubic parabolic transition is used, the minimum length of which is c × 85 000 feet.
Chinese Government Railways	Cubic parabola, spiral or any other type may be used.	With curves of 4° (437 m. radius) and over, not less than 55 m. (180 feet).	Transition curves are used with all curves of 2° (873 m. radius) and sharper. The cant is run off entirely on the transition.
Kansas City Southern Railway	Holbrook spiral type.	The curvature is increased by 1 minute per foot (305 mm.) of track.	...
Canadian National Railways	Holbrook spiral type.	...	...
South Manchuria Railway	Cubic parabola type.	Standard is 800 times the cant, the minimum allowable being 300 times the cant.	For curves less than 1 200 m. in radius. The minimum length of a circular curve to be left between transition curves in 30 m.
Pennsylvania Railroad	Holbrook spiral type.	Run-off of the cant, 1/2 inch in 33 ft. (12.7 mm. in 10.10 m.).	...
Illinois Central Railroad	Searles spiral type. Talbot spiral type.	...	...
Wabash Railway	Ten-chord spiral.	...	Curves requiring a cant of 2 inches (50.8 mm.) or more are to be spiralled. Where difference in degree of any two joining curves of a compound curve is more than 1° an intermediate spiral is inserted.
Richmond, Fredericksburg and Potomac Railroad.	Ten-chord spiral.	...	...
Buenos Ayres Western Railway.	Holbrook spiral type.	...	...
North Western Railway (India)	Cubic parabola type.	Not less than $8\sqrt{R}$ feet, where R = radius of the curve in feet.	The formula $8\sqrt{R}$ gives too great a length of transition curve for curves flatter then 2° (873 m. radius). For such curves a suitable length in feet is given by the formula: 6 × (max. permissible speed in m. p. h.).

TAB

RAILWAYS.	Gauge of track in mm.	Frog number.	Toe length of frog in mm.	Length of point rail in mm.
Federated Malay States Railways.	1 000	15	2 819	* 6 782
Cordoba Central Railway . .	1 000	10 10	2 210 2 210	3 658 4 572
Burma Railways	1 000	12	...	...
New Zealand Government Railways.	1 067	9	1 592	4 572
Sudan Government Railways .	1 067	12	1 854	4 572
South African Railways and Harbours.	1 067	9 9 12 12	2 154 2 154 2 350 2 350	4 064 4 978 4 978 6 172
Japanese Government Railways	1 067	10 12 16	1 855 2 500 1 600	5 000 6 000 * 6 000
Delaware and Hudson Railroad	1 435	10	...	...
Baltimore and Ohio Railroad .	1 435	8 10 12 16 20	* 1 372 * 1 829 * 2 134 * 2 591 * 3 048	3 353 3 962 5 029 7 315 9 144
Reading Company	1 435	8 8 10 12 15 20	* 1 880 * 1 880 * 1 880 * 2 438 * 2 438 * 3 048	4 572 6 096 6 096 6 096 9 144 9 144
Canadian Pacific Railway . .	1 435	11	1 969	6 706
Government Railways of Chosen	1 435	12 15	1 886 2 083	7 315 7 315
British Railways (Railway Clearing House).	1 435	16	2 946	8 687
Central of Georgia Railway .	1 435	10	...	5 029
Kansas City Southern Railway	1 435	12 12	* 2 311 * 2 921	6 706 6 706
New York Central Lines . . .	1 435	16 18	* 3 251 * 3 607	9 144 9 144
Canadian National Railways .	1 435	12	* 2 159	6 706
South Manchuria Railway . .	1 435	12 15	2 000 2 500	6 700 9 144
Pennsylvania Railroad . . .	1 435	8 10 15 20	* 2 134 * 2 134 * 1 829 * 2 388	5 486 5 486 9 144 9 144
Buenos Ayres Western Railway	1 676	10 12	1 918 2 413	5 486 5 486
Buenos Ayres and Pacific Railway.	1 676	12 16	...	5 486 7 315
North Western Railway (India)	1 676	8 1/2 12	1 978 1 943	5 472 6 401

...ad at heel ... switch ...n mm.	Angle of incidence.	Radius of lead curve in m.	Remarks.
127	...	...	* Flexible heelless switches are used.
...	...	...	...
...	...	...	...
114	1°21'11"	* 149.5	* Radius of the centre line of track.
...	...	...	...
132	...	...	...
132			
148			
148			
140	1°36'16"	160.1	* Curved point rails and movable frog are used.
140	1°20'13"	223.5	
131		530.2	
...	...	...	...
140	...	...	* Toe length to 1/2 inch (12.7 mm.) point.
140			
165			
165			
165			
152	1°49'50"	141.8	* Toe length to 1/2 inch (12.7 mm.) point.
162	1°27'45"	138.3	
162	1°27'45"	234.2	
162	1°27'45"	341.9	
152	0°54'55"	540.9	
152	0°54'55"	1 014.1	
159	1°18'08"	* 281.2	* Radius of the centre line of track.
146	...	348.5	...
146		564.7	
140	...	...	On high-speed lines the frog angle is seldom flatter than 1 in 16, though occasionally 1 in 20.
159	1°44'11"	237.7	...
159	...	413.3	* Toe length to 1/2 inch (12.7 mm.) point.
159			
159	...	...	* Toe length to 1/2 inch (12.7 mm.) point.
159			
159	...	...	* Toe length to 1/2 inch (12.7 mm.) point.
160	1°18'8"	347.4	...
160	0°57'38"	530.8	
...	1°29'32".1	139.2	* Toe length to 1/2 inch (12.7 mm.) point.
	1°29'32".1	234.2	
	0°53'43".0	562.5	
	0°53'43".0	1 049.0	
...	1°29'30"	280.0	...
	1°29'30"	400.0	
...	...	...	...
92	...	243.8	...
129		487.7	

On many railways, the extremity of the point rail is so designed that it gets on the bottom flange of the stock rail as both rails are in close contact. With this practice, there is no need for cutting the bottom flange of the stock rail, and renewal of the rail becomes easy.

Point rails are strengthened in the way shown in figure 26 on the Baltimore and

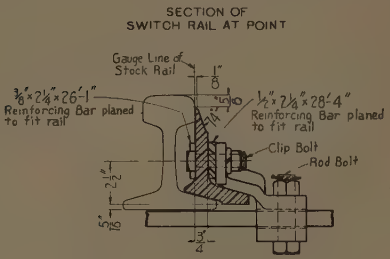


Fig. 26. — Reinforced point rail. (Pennsylvania Railroad.)

Ohio Railroad, New York Central Lines, Canadian National Railways, Pennsylvania Railroad, etc.

On the Japanese Government Railways, only one switch rod is used, because it has been ascertained that the second rod and those that follow have proved of no great value for increasing the rigidity.

The built-up frog is generally employed as standard, there being no great difference in its design on various railways.

The principal dimensions of turnouts in sections under high-speed train operation on the various railways are given in table 8.

Question 17. — ***What is your opinion about the movable crossing (or movable frog) and stab points (or stab switch) on the sections under high-speed train working?***

No stab switch is now adopted on the railways reporting to us. But the Japanese Government Railways consider it to be a favourable design for high-speed train working and are now contemplating its use on main line track.

Summing up the opinions of the various railways, however, it seems that its extensive use cannot be expected, as the first cost is higher than that of an ordinary split switch.

Some railways recommend the use of the movable frogs on turnouts in sections under high-speed trains, but others do not. The former are the Reading Company, Canadian Pacific Railway, New York Central Lines, etc. Among them, the Reading Company and the New York Central Lines have reported that these frogs have shown very good results. The South African Railways and Harbours and the Central of Georgia Railway reported that they are good where the angle is small. On the British Railways (Railway Clearing House) they have been used for trailing frogs alone, and as a result, the wear of frogs and wing rails has often been reduced. It has also been reported that movable frogs have been used for 8° 10′ (No. 7) frogs on the Illinois Central Railroad with satisfactory results. The Pennsylvania Railroad is of opinion that they may advantageously be used on sections under high-speed operation, so far as their designs are good.

But the Delaware and Hudson Railroad, the Baltimore and Ohio Railroad and the Canadian National Railways are of the opinion that they should not be adopted as far as possible, because of the difficulties in their maintenance.

The Japanese Government Railways are now enlarging the radius of curves on turnouts as far as possible, as their train speeds have been rapidly increasing. But this involves a smaller angle of frog and a longer broken line of gauge there. Therefore, the administration of the said railways believes that for ensuring smooth running of trains, a movable frog should be used at turnouts. Thus, a movable frog has experimentally been put in service on No. 10 and No. 16 turn-

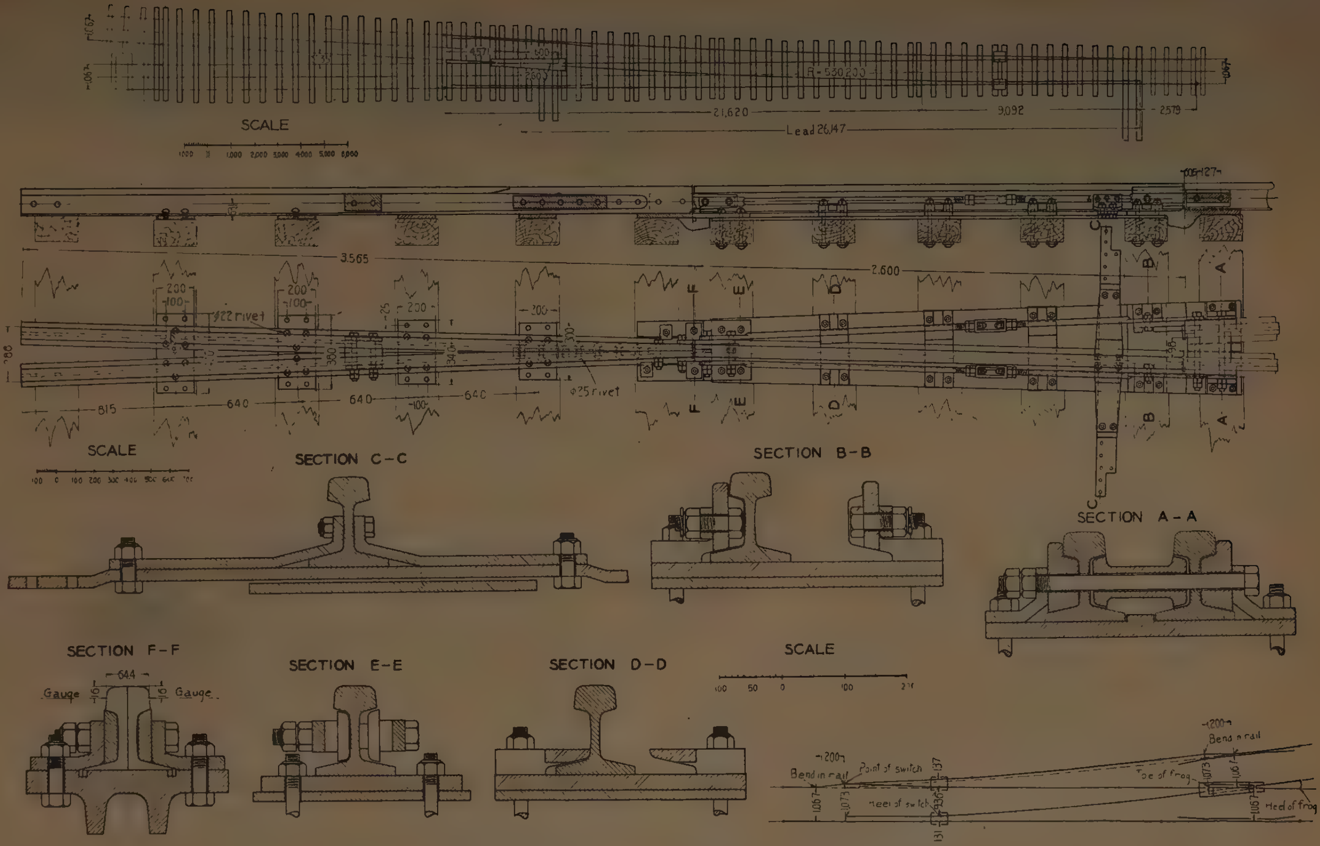


Fig. 27. — Movable frog on turnout (Japanese Government Railways).

outs, the construction of which is shown in figure 27. As a result, noise and vibration at the time rolling stock is passing through the frog, and wear of the frog have been reduced, and the wheel shock decreased.

In short, the use of a movable frog at turnouts in sections under high speed train working seems to be more advantageous for a small angle than that of ordinary rigid frogs, so long as it is properly designed.

Question 18. — *As to point rails for the sections under high-speed train working of your railway,*

I. *are such rails machined from ordinary or special rails?*

II. *do you adopt curved point rails or straight ones?*

III. *in what way do you decide on the angle of incidence?*

IV. *are longer point rails adopted by your railway?*

I. There are many railways where such point rails are machined from ordinary rails. On the Delaware and Hudson Railroad, point rails equipped with manganese steel tips are used where conditions are severe. On the North Western Railway (India) are used point rails machined from chrome steel rails. Point rails made from manganese steel rails are tentatively used on the Japanese Government Railways and the New South Wales Government Railways. Experiments are now being carried out by the New Zealand Government Railways on point rails made from silicon steel and sorbitically treated rails. Further, manufacture of point rails of special sections is now under contemplation by the Japanese Government Railways.

II. Straight point rails are chiefly adopted by most of the railways, but sometimes curved point rails are used for curved turnouts, slip switches, switches of the spring tongue type, etc., on the Madras and Southern Mahratta Railway, Baltimore and Ohio Railroad, Reading Company, British Railways (Railway Clearing House), New South Wales Government Railways, Chinese Government Railways and Illinois Central Railroad. On the Japanese Government Railways curved point rails are used for No. 16 turnouts alone.

III. The smaller the angle of incidence is, the smoother the running of rolling stock into a turnout becomes. But as the angle becomes smaller, point rails have to be made longer, which naturally requires a larger area for setting the switch and makes more difficult the throwing over of the switch. Moreover, the point of the switch becomes thinner and more liable to break. So, there must be a certain value of the angle of incidence that is the most advantageous. But the determination of such a value would be of high complexity, because it is dependent upon the construction of the rolling stock, the amount of traffic, the speed of the trains, etc. On several railways, therefore, it is determined on the basis of experience.

The South Manchuria Railway has determined the value in the following simple way.

The radius of the lead curve, which is required for a locomotive having the largest rigid wheel base being assumed, the angle of incidence α is calculated from the following equation (see fig. 28):

$$\cos \alpha = \frac{g\text{-}k\text{-}S \sin \theta + R \cos \theta}{R},$$

where θ = frog angle,
α = angle of incidence,
g = gauge,
R = radius of lead curve,
S = distance from theoretical point of frog to the toe,
k = clearance (spread) at the heel of switch.

A slack below 30 mm. (1.18 inches) is given to the theoretical point of switch having this angle of incidence, and it is to be ascertained whether rolling stock can get into the turnout. If rolling stock cannot do so, the angle of inci-

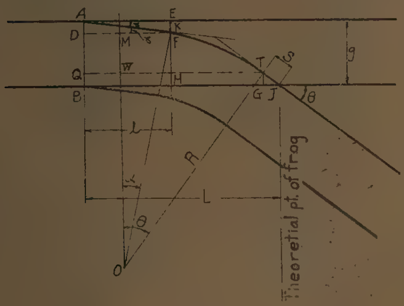


Fig. 28.

dence is to be made smaller by referring to the rigid wheel base of the rolling stock and to the radius of the turnout.

IV. The length of a point rail is below 6 m. (19 ft. 8 1/4 in) on almost all of the narrow gauge railways, only is it longer on the Federated Malay States Railways, where flexible point rails 22 ft.-3 in. (6.80 m.) in length are used for the No. 15 turnout. As regards the standard gauge railways, the Canadian National Railways have adopted the longest one, where point rails 33 ft. (10.10 m.) long are put in service for their No. 16 and No. 20 turnouts. Further, the New South Wales Government Railways are contemplating designing and trying point rails 40 ft. (12.20 m.) long. (See fig. 29.)

In conclusion, we may say that the angle of incidence must be made small in order that trains may run smoothly into a turnout, while point rails must not be made too long and have to be as strong as possible for the sake of handling and maintenance of switch. Curved point rails of special section are recommended for the purpose.

Question 19. — *Please let us know your opinion about the turnout which branches off the inside of the curved lines on the section under high-speed train working.*

This question may generally be considered from the following two points of view, that is, advisability of laying turnouts on curves of main lines under high-speed trains and what measures should have to be taken, if they are to be laid.

As to the former point, it may be said that most railways avoid such turnouts as far as possible, at least under the present circumstances. Only, the Kansas City Southern Railway lays a turnout on the curve where it is necessary, and the North Western Railway (India) has laid No. 12 or No. 8 1/2 turnouts, (of which the radius of lead curve shall not be below the minimum permitted for the track sections concerned) on a curved line, no special difficulties being said to be encountered on the two railways.

As to the latter point, the following conclusions may be drawn :

I. Such a turnout must be avoided as much as possible on very sharp curves; the radius of lead curves must be made as large as possible.

II. A regular cant must be maintained on main lines, even at turnouts.

III. Point rails and frogs must be made durable against wear.

IV. Restriction may have to be put to some extent on the speed of trains running over turnouts.

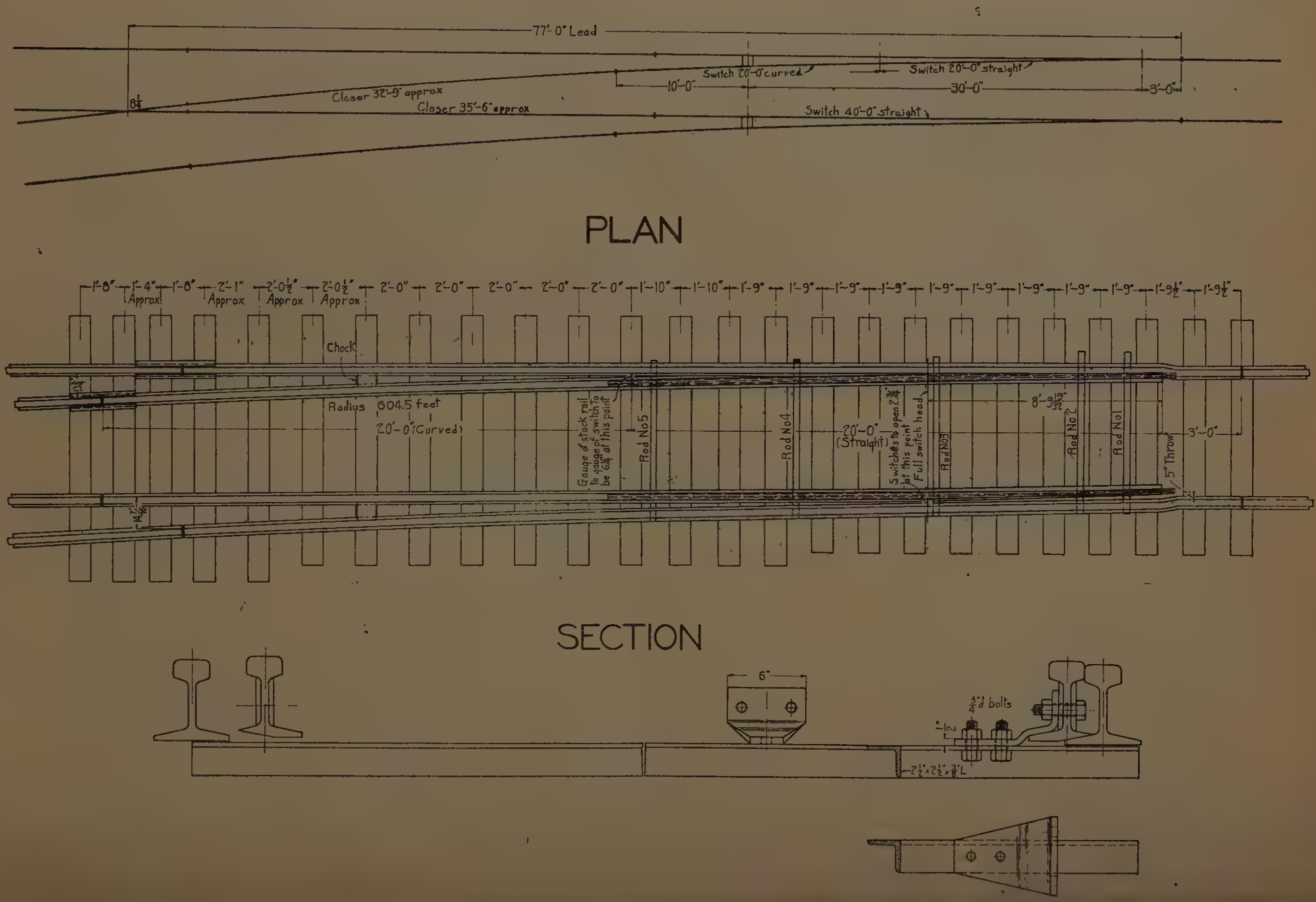
Question 20. — *We want to know the standard designs of check or guard rails to be laid on sections under high-speed train working with respect to the following :*

I. *Crossings.*

II. *Curves.*

III. *Bridges.*

IV. *Highway crossings.*


77'-0" Lead
Switch 20'-0" curved
Switch 20'-0" straight
10'-0"
30'-0"
3'-0"
Closer 32'-9" approx
Closer 35'-6" approx
Switch 40'-0" straight
PLAN
Approx
Chock
Radius 604.5 feet
20'-0" (Curved)
Gauge of stock rail to gauge of switch to be 6¼ at this point
Rod No5
Rod No4
20'-0" (Straight)
Switches to open 2¾ at this point Full switch head
Rod No3
Rod No2
Rod No1
5" Throw
SECTION
6"
¾"d bolts
2½"x2½"x⅜"L

Ordinary rails are now generally employed as standard guard rails on turnouts, their flange way being 35 mm. to 48 mm. (1.378 to 1.890 inches). But one-piece guard rails are used together with ordinary rails on the Japanese Government Railways, Baltimore and Ohio Railroad, Norfolk and Western Railway, Ca-

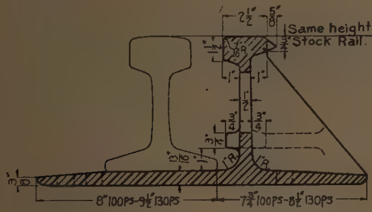


Fig. 30. — One-piece guard rail on frog. (Pennsylvania Railroad).

nadian Pacific Railway, Kansas City Southern Railway, Pennsylvania Railroad, etc. On many railways where such a practice is adopted, the flange way is adjusted as rails are worn (see fig. 30).

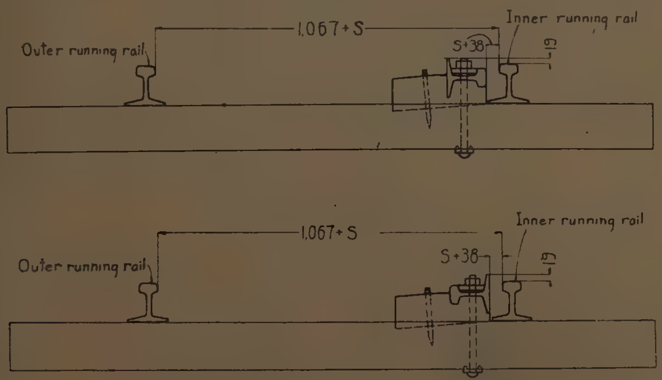
Generally speaking, guard rails are not used on curved tracks, so far as the railways reporting to us are concerned, and this seems to be due to the fact that there is no sharp curve in the sections of these railways where high speed trains are operated.

On the Japanese Government Railways, special guard rails are laid on curves of radius of less than 300 m. (14.91 chains). These are ordinary old rails which are placed along the inner rails and are laid on their side (see fig. 31). These rails not only prevent the derailment of wheels, but also remarkably decrease the wear of outer rails.

Though, generally, guard rails on bridges are placed exclusively inside the rails, they are sometimes laid outside the rails on the Japanese Government Railways and the British Railways (Railway Clearing House) (see fig. 32).

The clearance between guard rail and running rail is ordinarily 200 to 250 mm. (7.9 to 9.8 inches). Further, guard rails fitted with rerailer are placed in service on the Japanese Government Railways and the Illinois Central Railroad (fig. 33). Experiments on them by the former railway have proved them to be very effective.

Ordinary rails generally serve as guard rails on highway grade crossings.



Note: S = Slack.

Fig. 31. — Guard rail on curve (Japanese Government Railways).

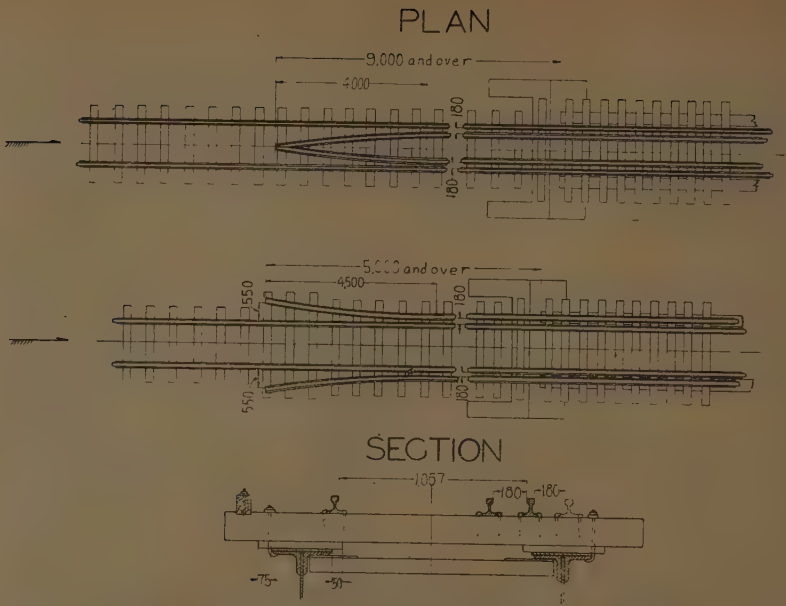


Fig. 32. — Guard rail on bridge (Japanese Government Railways).

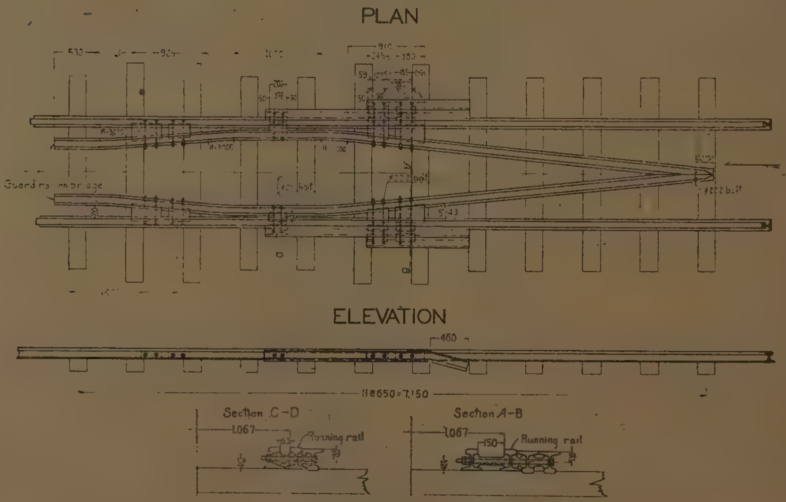


Fig. 33. — Rerailer (Japanese Government Railways).

They are laid on their side on the Federated Malay States Railways.

The angle at both ends of the guard rail, which it makes with the running rail must be small enough to minimize the shock against rolling stock. As a result of investigations made by the Japanese Government Railways, the angle is specified as about 2° 40′ on the same railway.

Guard rails on curved track are of value for reducing the wear of outer rails, but are not very favourable as regards smooth running of the trains.

Summary for Question III-B.

A resumé for Question III-B which has been prepared by refering to the answers from the various railways concerned is given in the following.

From the answers relative to Question III-A, it seems that ordinary rails weigh as many kilogrammes per metre as about 2.5 times the number of metric tons representing the greatest axle load. The corresponding figure for high-class lines on the Japanese Government Railways is about 3, which has been reached by taking into account the effects of lateral pressure and others, as well as economic considerations. It goes without saying that the construction of the track under high-speed service must be properly consolidated. For this purpose, rails of heavy section should be used, and careful consideration given to sleepers, ballast and fastenings between rail and sleeper. Generally, we may say that a good result will be obtained by fastening rails to wooden sleepers by means of tie-plates and screw-spikes and laying ballast of broken stone.

Use of longer rails as the standard, if proper measures are taken, will not only contribute much towards comfortable riding, but it will also lower the cost of track maintenance. According to the experience gained by the Japanese Government Railways, the cost of tamping at the rail joints amounts to some 53 % of the total cost of tamping the entire track; therefore the cost of labour for tamping is much lowered by the use of longer rails. But it seems that further consideration should be given to the handling of these rails and the extra charges for them. We think all the railways will be unanimous in admitting this fact. In this connection an extensive study has also to be made on electric welding of rail joints.

Dynamic effect by increased speed on rails and track is also a subject which demands our special consideration. The said Japanese Railways consider that it is one of the most practical methods to express the dynamic effect of a running train as increasing by x % the statical load for each additional kilometre per hour in train speed, and after numerous measurements and investigations, they now assume the aforesaid percentage as 1 % per 1 km. (per 0.621 mile) per hour.

As to this subject, the apparatus such as the magnetic strain gauge of the Westinghouse Co. and the stress recorder of the Japanese Government Railways will be of great value for the determination of the carrying capacity of rails.

As for equipments on curves, care should be taken of the minimum radius of curve run through by rolling stock with no speed limitations for curvature, amount of cant or super-elevation of outer rails, length of transition curve, slack or widening of gauge, length of tangent to be inserted in a reverse curve, etc.

Summing up the answers from the various railways relative to these points, we may say that where no limits are specified because of curvature, the minimum radius of curve is about 600 m. (30 chains), and the maximum amount of cant is about 150 mm. (6 inches) for the standard gauge railways and about 100 mm. (4 inches) for the narrow gauge (1 067 mm. = 3 ft. 6 in.) lines.

The length of transition curves varies with railways. Longer ones are of course better, while it must be borne in mind that the vibration of rolling stock should not be accelerated when it passes through the transition curve, the stiffness of the bearing springs of the rolling stock then being taken into account. Widening of gauge is naturally governed by the radius of curvature and the rigid wheel base of the rolling stock. Where there is no transition curve, it is not advisable to give slack to the straight line over too long a distance, as an excessive allowance would cause undesirable lateral movements of rolling stock with smaller rigid wheel base. It is no doubt good to insert a long tangent between branches of a reverse curve. According to the answers received, the length of the tangent is 13.70 m. to 61 m. (45 to 200 feet) for the standard gauge railways, while it is specified as 10 m. (33 feet) on the Japanese Government Railways in accordance with local and other conditions. In this connection we may say that a study should be made on the rotary inertia of the body of rolling stock.

Referring to the useful data as regards the turnout, we may conclude that, where express trains pass through stations, turnouts should be improved so as to be adapted to the operation of high-speed trains, even at the cost of other tracks.

[621 .132.8 & 625 .616]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

12th SESSION (CAIRO, 1933).

QUESTION XIII:

Use of rail motor cars on secondary railway lines.

REPORT No. 2

(*Continent of Europe, except Italy*),

by F. LEVEL,

Directeur de la Compagnie générale de voies ferrées d'intérêt local (France).

FIRST PART.

At the present time, the use of rail motor cars as one of the elements of the modern operation of secondary lines is no longer contested by anyone.

The satisfactory results obtained with their use, recognised by all railway operators, have been brought to light particularly in a time of crisis, which more than ever makes the economy of operation a vital question for every railway.

In face of the ever-growing interest of this question, the author, in agreement with his colleagues who were dealing with other countries, endeavoured to draw up a sufficiently detailed questionnaire, intended to throw light on the points which we deemed of the greatest interest.

Unfortunately, as regards the present report, we have only received 28 replies, distributed as follows :

France	17
Belgium	2
Finland	1
Norway	1
Denmark	1
Switzerland	1
Sweden	1
Holland	1
Rumania	1
Jugoslavia	1
Czechoslovakia	1

The rather small number of replies to our Questionnaire relative to Continental Europe excepting Italy, and the complete absence of information on the present state of the question in certain countries, particularly Germany have prevented the report from being as complete as might have been desired.

All the information obtained from the replies received has been grouped in the form of three tables to be found in the appendices.

Appendix I gives the principal features, from the technical point of view, of the different types employed.

Appendix II gives the conditions under which these various types are employed.

Appendix III gives the financial results per motor car-kilometre.

Each of these tables is divided into two parts :

1. « Light rail motor cars » (of a weight empty of less than 15 tons).

2. « Heavy rail motor cars » (of a weight empty over 15 tons).

This division will be followed in the report, a 3rd part being added, however, under the heading « Special rail motor cars ».

The author begs to be excused for any errors which may have crept into these tables, and in this connection, it may be

stated, that some of the information was not as clear as might have been desired.

However, if there are any such errors, they can easily be cleared up in the course of the discussion.

1. Light rail motor cars.

It is expedient to divide this chapter into two parts :

a) Rail motor cars of the « Rail motor-bus » type differing in principle from the road vehicle merely by the wheels being adapted to the rails;

b) Rail motor cars of the « Railway » type, of moderate power, larger capacity and permitting, if necessary, a trailer to be added on ordinary gradients.

a) « Rail motor-buses » of low tare and comparatively low price, but nevertheless capable of accommodating 25 to 30 passengers, have rendered, and are still rendering, good service on lines with little traffic, and fill in the gaps in steam operation, in regions insufficiently provided with transport.

It is not intended to dwell on this type of vehicle which has not undergone any considerable modification and which is well known to everyone (see Appendix I). It will merely be stated that the present expenditure per kilometre, based on an experience of 9 years, varies from 1.046 fr. to 1.50 fr. (1.683 to 2.414 fr. per mile);

b) « Railway » type motor cars of moderate power (4 and 6-cylinder petrol engines of 24 to 40 nominal H. P.; 45 to 110 actual H. P.) have likewise undergone very little change.

It will merely be recalled that this type of vehicle has more often two driver's cabs. There is a tendency, however, in some countries, particularly Czechoslovakia, for central driving to be developed for normal gauge rail motor cars when the clearance permits, although this last arrangement, except in cases of special necessity, does not appear to be advisable from the point of view of visibility.

It may be pointed out, however, that there is a need for the various kinds of vehicle comprised within this category to be standardised in a few types.

This point is being examined in France, and the characteristic features of one of these types are, for instance, as follows, as regards the metre gauge track:

Capacity of 30 to 40 places; Diesel engine; frame with two parallel axles, one only being a driving axle; speed 50 km. (31 miles) per hour on the level.

In view of the necessity for obtaining average speeds of the order of 40 km. (25 miles) per hour for the metre gauge track and of the practical impossibility, except in obviously special cases of profiles and lay-out, of exceeding on most lines of local importance a speed of 50 km. per hour the economy resulting from the use of the Diesel engine would be turned to advantage by choosing flexible engines, having a large reserve of power and capable of giving a working speed of 40 km. on 30-mm. (1 in 33) gradients.

Thus, by reducing the weight of the vehicles as much as possible, the necessary average speed for trains of this type would be obtained, enabling road competition to be met with some chance of success without, however, incurring the risk of trouble or accidents likely to result from an excessive maximum speed.

Thus, an advantageous repercussion on the cost of the vehicle would likewise be obtained, because the restriction in speed will naturally result in a reduction in the necessary wheel base and permit of the use of two parallel axles capable, at this speed, of running through small radius curves.

This type of vehicle will have one or two driver's cabs with, in the first case, a very simple turning device capable of being manipulated by two employees at the most.

Such standardisation, apart from the numerous advantages, particularly of cost, which are always inherent to it, will

be likely to reduce very considerably the delays caused in the delivery of spare parts by the diversity of types. Such delays which may extend to several months, have so far caused considerable inconvenience in operation.

The rail motor cars of the category of the « Light rail motor cars », in regard to which replies have been received, are all driven by petrol engines. In the case of some vehicles, however, the original petrol engines are being replaced by Diesel engines (the consumption will pass from 41 l. (9 Br. gallons) of petrol to 19 l. (4.17 Br. gallons) of gas oil and the anticipated saving is about 0.70 fr. per km. (1.126 fr. per mile).

The change speed gear is operated by hand; transmission is mechanical and heating is effected in most cases by the exhaust gases. In cold countries, however, coke stoves or auxiliary heating boilers are provided. Electric lighting is provided in all cases, except on old vehicles.

The average costs per rail motor car-km. *(per rail motor car-mile)* are as follow :

For the metre gauge : from 1.40 fr. to 2.784 fr. *(2.253 to 4.480 fr.)* [most of the figures fluctuate round about 1.80 fr. (*2.897 fr.* per r. m. car-mile)] (see Appendix III).

For the standard gauge : from 2.280 to 2.93 fr. (*3.669 to 4.715 fr.* per r. m. car-mile) (see Appendix III).

In this category, however, we find costs per km attaining 4.85 fr. (*7.805 fr.* per mile) for the standard gauge and 5.31 fr. *(8.545 fr.)* for the metre gauge track. This last result is probably due to a service of a special nature (crossing a town) and to a small mileage per day (37.5 km. = 23.3 miles).

The above figures are based on experience attaining six years.

Reference may be made, in this category, to the tests carried out by the Midi Railway with a light rail motor car which constitutes a novelty.

This vehicle has seating accommodation for 61 persons and a capacity for 1 000 kgr. (2 200 lb.) of luggage, in place of which it can carry about 20 passengers standing, for a weight empty of only 6.5 t. (6.4 Engl. tons).

The total weight when loaded, including 2 000 kgr. (4 400 lb.) of fuel (gas oil) is 12 t. (11.8 Engl. tons).

We thus have a rail motor car which is really light and of large capacity. Its overall length is 12 m. (39 ft. 4 1/2 in.) and its two axles have a wheel base of 6.94 m. (22 ft. 9 1/4 in.).

The tyres are of steel. The frame and body are of the one-piece type and made entirely of duralumin. Its engine (3-cylinder, 80 H. P., Junker-Diesel) gives a speed of 80 km. (50 miles) per hour for a consumption of 16 litres of gas oil per 100 km. (5.66 Br. gallons per 100 miles). Thus, with its fuel reserve, it can cover a distance of about 1 200 km. (745 miles) without re-fuelling.

The trials made with this vehicle have been fully satisfactory. Due to its low inertia, it starts up and stops with extreme rapidity. To indicate this, it may be stated that between Bordeaux and Le-Verdon, the test vehicle was able to cover the distance of 100 km. (62 miles) in 1h. 45 m. with *22 stops,* whereas the regular express takes 1 h. 40 m. to cover the same distance with only *3 stops*.

This vehicle costs about 390 000 fr. and according to expectations the saving to be realised ought to be more than 3 fr. per km. (4.8 fr. per mile) on the present form of operation.

The Midi Railway Co. are providing for the construction of other types, one of which, adapted for very high speeds, will be mounted on two driving bogies having three axles, and the other, intended for the steep gradient lines crossing the Pyrenees will be equipped with « Kegresse » caterpillars adapted to rail use.

Further information is lacking on this obviously special point.

It may likewise be pointed out that the same railway has under consideration at the present time a large capacity type of rail motor car which would be reserved for goods and would effect pick-up, sorting while running and distribution of parcels. This motor luggage van would travel on different lines with a frequency suitable for the traffic.

Thus, the use of light rail motor cars is making very distinct headway as regards both capacity and performance. It is evident that these vehicles, originally intended for lines of local importance, are about to be put to a use which could not have been foreseen even quite recently.

However, a warning must be uttered against the tendency to consider that the rail motor car ought to run alone and consequently that it is useless to provide this vehicle with the buffering and traction gear with which it has been equipped up to the present.

At the most, some companies prefer to provide a device for enabling it to be coupled to another rail motor car, with a view to their running as one unit.

As far as we are concerned, we believe that this is a mistake and that to proceed thus would be to depart from the general principles of the use of rail motor cars, while at the same time relinquishing some of their advantages.

In fact, we consider that the provision of these vehicles with ordinary coupling gear is indicated for the following reasons :

1. In case of trouble with the vehicle, it may be necessary to couple the rail motor car to a break-down engine or at least to include it in a train for returning it to its depot. It cannot be believed that, in most cases, there would be in the vicinity, apart from the reserve motor car for continuing the service, another vehicle for returning the damaged vehicle to its depot.

2. We do not think it may be stated, *a priori*, that there will never be any need for trailers. The latter may be very useful in many cases and may make it possible to meet either an unforeseen rush of passengers or operating conditions depending upon local requirements.

3. Finally, it is of avantage that, apart from its ordinary use, the rail car may be used as reserve in place of the locomotive, and consequently is capable of hauling at least the emergency wagon or a coach for removing the passengers of the disabled train.

Or course, we are chiefly concerned here with secondary lines having little traffic, on which the mixed service of steam train and rail motor car is in favour. Due to its coupling gear, the rail motor car is able to replace the reserve locomotive kept under steam as required by the regulations, thereby providing a substantial saving on which it is unnecessary to dwell.

For these various reasons, the writer believes that it is necessary to continue to provide rail motor cars with their present buffering and traction gear, the expenditure involved being moreover a negligible item in comparison with the total cost, while it renders possible more extensive use.

Mention may also be made in this category of rail motor car of a type of vehicle constructed in Germany and shown at the International Automobile Exhibition in Berlin in 1931. This vehicle is built by one of the largest locomotive works in Germany and is at present under test.

Properly speaking, this is a rail motor bus, or more exactly a unit of two rail motor buses joined end to end and therefore capable of running in both directions. The novelty of this vehicle resides in the steel-tyred wheels which have been specially designed to adapt themselves to the stresses to which a railway vehicle is subjected, namely :

Elastic absorption of the vertical shocks at the rail joints;

Absorption of the lateral shocks on running through points;

Elastic transmission of the starting and braking stresses.

These conditions are obtained by a type of wheel comprising rubberised fabric discs, similar to the « Hardy » flexible discs commonly used on motor cars, especially on certain flexible couplings. All these discs are held together by bolts and connected to the hub by an element having projections and which is integral with the hub. The movements in all directions, of course, are so calculated that these canvas-mounted rubber discs are subjected to normal stresses.

Tests are now being made and the results are not yet known, but the idea appears to be interesting.

It should also be pointed out that the end-to-end coupling of two motor bus chassis provided with these special wheels may provide either a single vehicle comprising 33 seats in addition to the lavatories and equipped with one driver's cab, or a vehicle comprising 66 seats and capable of running in either direction without turning round.

Moreover, the chassis being identical with that of the motor bus and motor lorries commonly constructed, it is possible for it to be manufactured by mass production, thus realising a saving. In this connection, the constructors indicate a reduction capable of attaining 25 % of the cost of an ordinary rail motor car of equivalent accommodation.

Finally, it may be pointed out that, at the instigation of one large railway, in France, a competition has been opened for the construction of a type of rail motor car. Particulars regarding this competition are given below to show the present tendency regarding this aspect of the question.

The single-class vehicle must accommodate at least forty passengers seated and ten standing. It must be provided with a luggage compartment capable of accommodating at least 1 000 kgr. (2 200 lb.). The engine must be a heavy oil engine and readily detachable.

The maximum speed of 90 km. (56 miles) per hour on the level must not fall below 60 km. (37.3 miles) on a gradient of 15 mm. (1 in. 66). The braking shall be such that the vehicle propelled at its maximum speed (90 km.) on a gradient of 5 mm. (1 in 200) will stop within a distance of 120 m. (395 feet) at the maximum.

The rail motor car may only be provided with a single driver's cab on condition that its wheel base enables it to be turned on a 5.80-m. (19-foot) turntable.

2. Heavy rail motor cars.

These rail motor cars, which we have defined as having a weight greater than 15 t. (14.76 Engl. tons) have up to the present been employed very little in France, but they are very extensively used in many other European countries.

This type of vehicle is propelled by petrol engines and to an increasing extent by Diesel engines of from 75 to 200 H.P. or even greater.

We shall only consider here the real rail motor cars of a weight of up to 40 t. empty and accommodation about a hundred passengers. We shall leave aside the tractors, the power of which often attains 440 H.P. and which haul veritable trains.

The principle types of Diesel met with are the following :

Deva and Man, 75 to 90 H.P.
Hawa, 90 H.P.
Wegman, 90 H.P.
Maybach, 150 H.P.
Sulzer and Brown-Boveri, 250 H.P.

The change speed gears are operated by hand, compressed air, or compressed oil.

Transmission is mechanical or very frequently electric. This latter method, moreover, despite its cost and the increase in weight, appears to be preferable for the transmission of high powers.

Special devices are provided, such as the « dead man's handle », portable tele-

phone, roller bearing axles, anti-rolling device, etc.

The cost per kilometre *(per mile)* of rail motor cars of this category, for which we have had replies (standard gauge rail motor cars) is as follows :

From 0.970 fr. to 3.981 fr. (1.560 to 6.405 fr. per mile) (see Appendix III).

We also find a cost of 6.92 fr. (11.134 fr. per mile) which, it is true includes depreciation and relates to a gas-producer rail car.

This type does not appear to have given the results expected, since this vehicle, the only one mentioned, has been under repair for more than a year after running only 4 000 km. (2 485 miles).

Among these types of heavy rail motor cars, the cost of which per kilometre compares favourably with that of light rail motor cars, reference should be made to the type operated by the Belgian National Railway Company. This Company owns three of these vehicles which, despite the characteristics given below, only cost 1.65 Belgian francs per kilometre or 1.169 French francs (1.88 French francs per mile).

These standard gauge rail motor cars, of a weight of 40 t. (39.4 Engl. tons) empty (47 t. = 46.25 Engl. tons loaded), offer an accommodation of 92 places seated and 40 standing.

There is no luggage compartment nor postal compartment. The engine is a Diesel-Maybach having 6 vertical cylinders in line and developing 150 H.P. at 1 350 r. p. m. [engine with fuel injection by compressed air at 125 kgr. per cm^2 (1 777 lb. per sq. inch) of the so called « compressor » type].

The clutch is a hydraulically operated friction clutch. The transmission is mechanical with gear box having four sets of constant mesh gears.

The commercial speed without trailer is 40 km. (25 miles per hour and the maximum speed is 65 km. (40.4 miles). The consumption is 42 l. (gas oil) per 100 km. and 1,5 to 2 kgr. of lubricating oil (14.86 Br. gallons of gas oil and 5.3 to 7.1 lb. of lubricating oil per mile).

This type has been on trial for about a year. The breakdowns which have occurred have been due to compressor valve fracture.

In this connection, it should be pointed out that the most frequent instances of breakdown of the Diesel engines at present in service are due to the compressor or more exactly to the necessity, in « direct injection » engines, for high compression. Some administrations have, moreover, decided to employ in future only compressor-less Diesel engines.

However, it would be inaccurate to compare the cost of the two types of rail motor cars we have just discussed on the results alone which we have received, because they only relate to a small number of replies and, except for a few cases, are only based on an experience of brief duration.

Still, it should be pointed out that the Swedish Railways, after an experience of 7 years in Diesel-electric rail motor cars, of 39 t. (38.4 Engl. tons) loaded, have attained costs which are the lowest of those received and vary between 0.972 fr. and 1.2125 fr. (1.564 and 1.95 fr. per mile).

This apparent anomaly is due to the fact that, in most cases, the heavy rail motor cars for which we have received replies to our questionnaire are propelled by Diesel engines, and that therefore the cost of fuel is negligible compared with that of petrol engine (the Maybach Diesel of the Belgian National Railway Company only costs 0.177 fr. of fuel per km. [0.285 fr. per mile] for 150 effective H.P.).

In order to make a fair comparison, it is necessary, in the case of the light rail motor car, to refer to the test which the Midi Railway Co. have just made and which has already been mentioned.

We then see that the consumption of the Diesel engine on this rail motor car,

which weighs 12 t. (11.8 Engl. tons) loaded, is only 16 l. per 100 km. (5.66 Br. gallons per 100 miles) whereas the consumption of the Belgian National Railway Company's vehicle of 47 t. (46.3 Engl. tons) loaded attains 42 l. (14.86 Br. gallons per 100 miles). Assuming that the other expenses in staff and maintenance remain the same (and they will certainly be much less with the light rail motor car), we obtain for the fuel item alone, a saving of 26 l. of gas oil, i. e. 14.30 fr. per 100 km. (9.20 Br. gallons or 23 francs per 100 miles) counting on gas oil at 550 fr. the ton.

It is beyond doubt that the heavy oil engine has a tendency to gain many supporters and that the cost per kilometre of light rail motor cars will be reduced considerably further when these cars are equipped with this type of engine. This considerable reduction in the working costs will not be the only improvement procured by this type of engine because, as was pointed out previously, it will be more easily possible to enjoy the luxury or rather the advantage of flexible engines having a large reserve of power, an essential condition for satisfactory efficiency in operation, whereas the power of petrol engines fitted on similar rail motor cars is in some cases rather low, involving trouble in operation, and breakdowns.

It is not within the scope of this report to make a panegyric of the heavy oil engine. We may be permitted to state, however, that the disadvantages with which this engine was afflicted at its beginning have now practically all disappeared, particularly those relating to its weight, its bulk and its starting. There is one disadvantage still existing, a serious one it is true, and this resides in the smoke and smell given off by the exhaust gases, a disadvantage which must be taken into consideration in view of the operating conditions.

Nevertheless, we do not believe that this disadvantage is a serious obstacle to the development of this type of engine, which is in other respects of such interest, and the constructors who have understood perfectly all the importance of it, from the point of view of transports in common, are endeavouring to suppress it.

It appears that some engines are already perfectly satisfactory from this point of view. The writer has not yet been able to acquaint himself of this personally, but the results of official tests made in France show that the Mercedes-Benz Diesel, for example, gives off practically no smoke nor smell.

The exhaust gases have also been analysed. One of the results obtained, under full load, with a 6-cylinder Diesel engine of this construction using « Derop » fuel of a specific gravity of 0.855 is as follows :

At 1 300 r.p.m. the analysis showed 10.8 % carbon dioxide, 6.2 % oxygen and no carbon monoxide. This last result undoubtedly indicates complete combustion.

These tests appear to be conclusive and if we compare them with the facts mentioned above, namely that the present form of this type of engine does not differ materially from that of the petrol engine, that its weight has become quite admissible and that its flexibility is also comparable to that of petrol engines, it would not appear imprudent to predict a well-deserved success for the heavy oil engine.

In regard to its weight and flexibility, it is interesting to note the progress made, which will be appreciated if it is remembered that in 1914 the weights per H.P. and the speeds for this type of engine were still of the order of 250 kgr. (450 lb.) and 150 r.p.m., whereas at the present time 7.5 kgr. (16.76 lb.) per H.P. and 1 700 r.p.m. have been attained.

What is of importance is that this result permits the substitution pure and simple, on a vehicle, of an engine of this

type for a petrol engine without in many cases changing the existing speed gear.

The Mercedes-Benz Diesel is also capable of using a large variety of oils :

Gas oil — palm oil — lignite oil — shale oil — arachid oil, etc.

This engine is based on the principle of the preliminary combustion chamber of quite a special shape connected to the cylinder by the burner. By means of this construction, it is possible to admit fuel to the cylinder at pressures five or six times less than in the case of direct injection engines, the risk of breakdown being reduced in proportion.

It has a special piston for utilising the well-known « turbulence » principle. Slow running is on the « hit or miss » principle, part only of the group of cylinders working rationally, while the others do not develop any power at all.

It appeared of interest to mention this type of heavy oil engine which even at this juncture seems to be quite satisfactory, and the writer hopes that, at the time of the discussion of this report, he will be in a position to provide additional practical information regarding the behaviour of this engine in service.

To conclude this question, it is to be hoped that Governments, in view of the development of heavy oil engines, will not apply to gas oil and the like the taxes which are at present levied on petrol, for in such case, these engines would immediately lose most of their advantages and railway operators would find their idea of engines with a large excess of power turning back on them.

3. Special rail motor cars.

This chapter will include the accumulator rail cars used by some French railways, particularly by the « Compagnie de Chemins de fer Economiques des Charentes », and which are giving good results.

It will be recalled briefly that the new vehicles in service have benefited by an appreciable reduction in weight which, while enabling the length of the vehicle to be increased by 0.70 m. (2 ft. 3 1/2 in.), has reduced the total weight from 27.5 t. to 25 t.

This gain has been effected on the iron-nickel battery which, constructed according to the true « Edison » type, has had its weight reduced from 8.5 t. to 6 t.

The improvement of the recuperation system and the gain in weight have resulted in an appreciable economy over the old type, this economy attaining 20 % per ton-kilometre. The consumption in watt-hours per ton is at present 33 as against 42 for the old type.

The cost of motive power, per rail motor car-km. is on the average 0.50 fr. (0.80 fr. per mile). The data necessary for giving the total cost per kilometre for these vehicles are not available.

It may be added that accumulator rail motor cars enjoy considerable favour in Germany (where 180 rail motor cars of this type are in regular service) and also in Italy.

We now come to the « Michelines » the recent appearance of which has given rise to numerous reports, their novelty particularly having attracted considerable attention.

The idea of adapting the pneumatic tyre for rails is not new, but necessitated considerable research and experiments.

At the time of writing this report, the use of Michelin rail cars is still in the trial stage, but it is probable that by the time the question is discussed new facts will have come to light which will enable an opinion to be formed in regard to this question.

Be that as it may, it cannot be denied that this initiative is interesting and we cannot remain indifferent to it.

Due to the pneumatic tyre, the automobile has been able to make the marvellous progress of which we are aware, having become one of the most remarkable means of transport in existence. The position of rail vehicles, all proportions being observed, is not unlike that of the

automobiles of the heroic period provided with rigid tyres, on which no form of suspension was able to avoid fractures of all kinds.

The rail, however, represents a far better running surface than the road, but its dimensions are such that the pneumatic tyre, in its present state, is incapable of supporting a load greater than 700 kgr. (1 540 lb.) maximum.

Hence the necessity for providing a vehicle, which has to have 24 places seated, with five axles.

Although the features of the Michelin rail cars are known, they will be enumerated briefly below, but only in so far as concerns the Michelin rail car No. 9 with 24 places seated.

The Michelin rail car No. 5 with 12 places will be left out of consideration. This is a trial vehicle for demonstrating the possibilities of the system and is composed of an aeroplane fuselage type body on a Hispano 46-H.P. chassis.

The Michelin rail car No. 9 (24 places seated) weighing 4 370 kgr. (9 640 lb.) empty, has been constructed for a useful load of 2 160 kgr. (4 760 lb.). The weight of 6 530 kgr. (14 400 lb.) loaded is distributed over two bogies: one having three axles (front) and the other having two axles. The load carried by each axle is thus 1 306 kgr. (2 880 lb.) or 653 kgr. (1 440 lb.) per wheel. The driving bogie (front three-axle bogie) is driven by its central axle after the manner of the driven axle of an automobile.

The rear axle of this bogie is merely a carrying axle. The front axle is connected by roller chains to the driving axle.

The rear bogie (two axles) is a carrying bogie. Two special shock absorbers control the movements of the body.

The engine is a valveless Panhard and Levassor of 20 nominal H.P. The speed gear is of the automobile type with four speeds and one reverse. The ribbed radiator is of the Lamblin aviation type. All the axles are braked by the Lockheed system of hydraulic operation.

The speed may attain 100 km. (62 miles) per hour; the normal speed is 90 km. (56 miles); consumption is less than 20 l. (7.08 Br. gallons per 100 miles).

The Micheline wheel is built up of a web of pressed steel forming a flange on which is mounted the special pneumatic tyre of the « straight side » type held on the rim by a detachable plate.

The profile of the tyre is not symmetrical with respect to the median axis of the wheel, the diameter increasing progressively towards the flange. Within the air chamber is a rigid crown of suitably designed profile for counteracting any deflation or burst. In either of these two cases, the collapse is less than 1 mm. (3/64 inch).

The test of rapid deflation at speed was made, moreover, at the time of the introduction of this vehicle, on the section St. Arnoult-en-Yveline to Goltainville, the passengers experiencing absolutely no sensation of shock.

The tyre, the tread of which is specially designed, is capable of covering 20 000 km. (12 400 miles).

The pressed steel web forming the flange lasts longer and may be replaced when worn.

The advantage of the pneumatic tyre, apart from its power of running smoothly over fairly large obstacles, chiefly resides in the fact that its adhesion on the rail attains 0.62, i.e. a value three times that of the steel tyre.

This is undoubtedly due to the pressure (6 kgr.) on the rail, since it is curious to note that the solid rubber tyres which have been tried did not give an adhesion materially greater than that of steel tyres.

The adhesion in rainy weather is reduced by about 1/10 and experience has shown that, after the first axle has expelled the water off the running surface, braking of the following axles is normal.

The average accelerations obtained, irrespective of the weather, are as follows:

On starting: A speed of 80 km. (50 miles)

per hour is obtained in a distance of 800 to 900 m. (2 625 to 2 952 feet).

On braking : 100 m. (328 feet) is sufficient for stopping from a speed of 80 km. (50 miles) per hour,

i.e. accelerations of 0.31 and 2.46 m. (1 and 8.07 feet per second respectively.

Apart from the really unique comfort and silence, the pneumatic tyre also provides the possibility of attaining high speeds even on tracks which are far from perfect. In this connection, it may be mentioned that, on a rather badly kept strategic track, the Michelin cars have been able to attain speeds of 120 km. (75 miles) per hour without difficulty, while the maximum permissible speed is usually only 60 km. (37 1/2 miles).

As already stated, the use of the pneumatic tyre has not yet left the experimental or test stage, and while noting the interesting results which have already been obtained, it will be necessary to wait until it has been used in regular operation for a sufficiently long time before passing a final opinion.

SECOND PART.

All the Administrations who have replied to our questionnaire consider the rail motor car to be one of the fundamental factors in the modern operation of secondary lines.

It is always necessary, of course, to take into consideration local conditions and the requirements of the traffic, but it may be asserted that the present tendency, in view of road competition, is to develop as much as possible, on these lines, the passenger service by rail motor car, reserving steam traction for goods service when circumstances permit.

In practice, the present accommodation (40/50 places) of rail motor cars is sufficient in most cases. Since the days of « rush » traffic, such as markets, fairs, local fetes, etc., are known beforehand, it will be possible on such days and on certain routes to add a trailer, or to run an extra rail motor car or to run a steam train.

It is, however, obvious that one cannot generalise by stating that it will always be possible to « revive » a line by making use of the rail motor car.

These are mostly special cases which arise, and in the case of a line with very little passenger and goods traffic, it seems that the motor bus may be a serious competitor.

It will always be permissible for the motor bus to deviate for a few miles in order to work an important centre or even to pass through a densely populated area, remote from the station, and this advantage counts in regard to customers.

What is certain is that the use of rail motor cars on lines with sufficient goods traffic is likely to keep the passengers which are still left to them.

In order, however, to obtain this result, the rail motor car must satisfy certain conditions, and particularly, its starting and braking accelerations must be good enough to give a commercial speed of the order of 40 km. (25 miles) per hour for metre gauge lines.

It is also necessary that is should stop frequently, as frequently as possible, in judiciously selected points, if it is to be fully utilised.

When understood in this way, that is to say, frequent and rapid services with numerous stops, the rail motor car ought to assist in retaining the present customers for the secondary lines, because it must surely be admitted that the rail motor car is more comfortable than the motor bus, that more generosity is shown in regard to the room offered to passengers, particularly in regard to hand luggage, and finally that the safety is likewise greater.

Reference may be made, in this connection, to the example furnished by the Belgian Light Railway Company who mention the case of the line from Andenne to Huy (12 km. = 7.5 miles)

where a motor bus, duplicating this line, deprived it of the greater part of its passenger receipts. A properly organised rail motor car service has eliminated all competition and has even increased the receipts.

The greater part of the railways who have replied to our questionnaire likewise consider it necessary for the rail motor car to be capable of pulling either a small passenger coach, or a fast-traffic truck (fruit, vegetables, cattle, etc.) so that, even in cases in which the goods traffic does not justify numerous trains, the consignees will not have to wait too long for their consignments.

This is also the opinion of the writer and, moreover, bears out the view previously advanced in this report, namely, the usefulness of continuing to provide the rail motor car with traction and buffering gear.

Let it be stated, however, that while reserving this possibility it must not be utilised to excess, particularly as regards the frequent hauling of loaded wagons, because the rail motor car would very soon depart from those conditions of economy which ought to constitute the principal advantage of its use.

Conclusions.

In short, the time of crisis through which we are passing has brought the question of rail motor cars to the front.

Whereas the railways of local interest have come to this quite naturally as a result of the pressing need for reducing their expenditure to the strictly necessary, the main railways also have appreciated the advantage they are able to derive from the use of rail motor cars on secondary lines and even on main lines by employing them to bring passengers from the intermediate stations to the stopping points of expresses.

We have seen that in France, especially, railway companies are paying particular attention to this question, and that tests are being carried out which even now enable the possibilities of the use of this type of vehicle to be appreciated.

Future tests will not fail to be particularly instructive in this respect and perhaps will be of a nature to bring about gradually a profound change in the present method of operation.

In regard to the present tendencies of rail motor car construction, two points stand out clearly :

1. The increasing use of heavy oil engines.

2. The endeavour to secure lightness.

It is to be hoped that the second point, which is so interesting particularly in regard to starting and braking accelerations, may be combined with the necessities of operation which have just been discussed in this report and thus enable secondary lines and lines of local interest to utilise *all* the advantages which they are entitled to expect from rail motor cars.

In conclusion, it appears permissible to believe that by taking advantage in this way of the considerable progress which has been made in the automobile, and by adapting this progress to their operating conditions, the railways, large or small, will be able, with some chance of success, and to the greater benefit of their customers, to meet the road competition which has grown so much in recent years.

Table giving the principal characteristics

ADMINISTRATIONS. 1	Gauge in metres. 2	Type. 3	Construction. 4
			Light ra
Czechoslovakian State Railways	0.760 1.435 1.435 1.435 1.435 1.435	11-0 120-0 120-1 120-2 120-3 120-4	Zavody-Tatra. Ceskomor-Kolb-D. Skovody-Zavody. Zavody-Tatra. Do. Do.
Jugoslavian State Railways	1.435	A.	Not stated.
Danish State Railways	1.435	M.A.	Not stated.
Norwegian State Railways	1.067 1.435	A. B.	A. E. G. A. E. G.
Belgian National Light Railways	1.00	A.	De Dion-Bouton.
	1.00	B.	Saurer.
Sud de l'Aisne Railways	1.00	A.	Not stated.
Aube Departmental Railways	1.00	J.M.	De Dion-Bouton.
Do. Meurthe-Moselle system .	1.00	J.A.	Do.
Indre Tramways	1.00 1.00 1.00	Kg. 2. J.M. « Deux-Sèvres » type.	De Dion-Bouton. Do. ...
Deux-Sèvres Tramways	1.00	A.	...
Loiret Tramways	1.00	A.	De Dion-Bouton.
Nord-Est Secondary Railways	1.00 1.00 1.00 0.60	Renault-Scemia R.S. 2. Do. R.S. 4. De Dion J.M. 2. Crochat C.L.	Renault-Scemia. Do. De Dion-Bouton. Crochat.
Compagnie Générale de voies ferrées d'intérêt local. Anvin-Calais line . .	1.00 1.00	Renault-Scemia R.S. 1. Do. R.S. 2.	Renault-Scemia. Do.
Do. Milly-Formeries line.	1.00	Do. R.S. 2.	Do.
Société de Transports en commun de la Région parisienne	1.44	Renault-Scemia R.S. 4.	Renault-Scemia.
Midi Railway Company (France)	1.44	Not stated.	Not stated.
Paris - Orleans Railway Company (Blan to Argent line)	1.00	Renault-Scemia R.S. 4.	Renault-Scemia.

different types of rail motor cars used.

Weight empty (in metric tons). 5	Weight loaded (in metric tons). 6	Number of places seated. 7	standing. 8
r cars.			
6.700	10.500	32 (3rd cl.).	...
6.965	10.600	31 (3rd cl.).	...
8.850	12.200	31 (3rd cl.).	...
7.900	12.400	32 (3rd cl.).	...
8.300	12.340	38 (3rd cl.).	...
11.000	14.680	46 (3rd cl.).	...
Not stated.	17.400	15 pl. 2nd cl.; 31 pl. 3rd cl.	...
...	11 (approx.).	24 pl.	...
10.000	Not stated.	24 pl.	...
14.000	Not stated.	42 pl.	...
6.600	Normal: 8.630. Exceptional: 9.180.	25 pl.	Normal: 4. Exceptional: 12.
6.340	Normal: 8.090. Exceptional: 9.290.	15 pl.	10 pl.
1.800	Not stated.	30 pl.	...
Not stated.	Not stated.	25 pl.	10 pl.
2.500	Not stated.	20 pl.	...
10.000	Not stated.	26 pl.	16 pl.
5.000	Do.	26 pl.	...
3.900	Do.	26 pl.	4 pl.
3.500	Not stated.	24 pl.	10 pl.
5 and 5.500	Not stated.	24 pl.	6 pl.
9.500	13.000	25 pl.	15 pl.
10.800	14.000	25 pl.	15 pl.
5.800	8.800	24 pl.	10 pl.
6.400	8.240	16 pl.	16 pl.
9.300	12.800	25 pl.	15 pl.
10.000	13.500	25 pl.	15 pl.
10.000	13.500	25 pl.	15 pl.
10.740	12.780	19 { 7 1st cl. 12 2nd cl.	13 pl.
6.500	12.000	61 pl.	20 pl.
9.000	13.000	25 pl.	15 pl.

APPENDIX I. (*Continued.*)

ADMINISTRATIONS. 1	Gauge in metres. 2	Type. 3	Construction. 4
French State Railways	1.44	Renault.	Renault.
Do.	1.44	Schneider.	Schneider.
Do. Pallet-Vallet line	1.44	Not stated.	Not stated.
Do. Vendée Tramways	1.00	Do.	Renault.
			Heavy rai
Czechoslovakian State Railways	1.435	210-0	Deutsche-Werke.
	Do.	220-1	...
	Do.	221-0	Ake-Spol.
	Do.	220-2	Zavoty-Tatra.
	Do.	230-0	Do.
	Do.	220-3	Do.
	Do.	251-0	Do.
	Do.	231-0	Do.
	Do.	221-2	Do.
	Do.	132-0	Moravsko-Slerzkà
	Do.	131-0	Do.
	Do.	122-0	Do.
	Do.	221-1	Brno-Kralovo-polska.
Danish State Railways	1.435	M.C., M.E., M.F., M.L.,	Not stated.
	1.435	M.R.	Do.
Norwegian State Railways	1.435	Deutsche-Werke.	Deutsche-Werke.
	1.435	A. E. G.	A. E. G.
Belgian National Railway Company	1.435	Diesel « Maybach ».	Not stated.
	1.435	Sentinel.	Sentinel.
Rumanian State Railways	1.435	A.	Westingh.
	1.435	B.	De Dion-Bouton.
	1.435	C.	Westingh.
Finnish State Railways	1.524	A.	Not stated.
	1.524	B.	Do.
Swedish State Railways	1.435	A.	Not stated.
Netherlands Railways	1.435	B. C. 1901-1903	Not stated.
	Do.	C. 1901-1910	Do.
	Do.	C. 901-908	Do.
	Do.	B. C. 1904-1910	Do.
	Do.	C. 911-916	Do.
Paris-Lyons-Mediterranean Railway Company	1.44	Renault.	Renault.
	1.44	Steam, Purrey system.	...
French State Railways	1.44	Renault, producer gas.	Renault.
Nord-Est Secondary Railways	1.44	Renault-Scemia P. S.	Renault-Scemia.

Weight empty in metric tons). 5	Weight loaded (in metric tons). 6	Number of places seated. 7	Number of places standing. 8
9.000	...	34 { 10 1st cl. 24 2nd cl.	...
14.500	...	20 pl.	...
Not stated.	15.620	40 pl.	10 pl.
8.900	Not stated.	25 pl.	10 pl.
or cars.			
20.000	26.000	55 3rd cl.	...
34.000	43.000	83 { 19 2nd cl. 64 3rd cl.	...
35.920	44.700	80 3rd cl.	...
32.000	42.000	72 3rd cl.	...
32.800	42.000	72 { 19 2nd cl. 53 3rd cl.	...
34.200	40.280	76 3rd cl.	...
39.000	45.000	68 3rd cl.	...
39.000	45.000	68 { 24 2nd cl. 44 3rd cl.	...
39.000	49.000	68 3rd cl.	...
19.800	26.000	52 3rd cl.	...
15.900	22.500	62 3rd cl.	...
18.000	23.000	48 3rd cl.	...
36.000	42.000	75 3rd cl.	...
20, 14, 15, 43	Not stated.	33, 33, 50, 70 pl.	...
44	Do.	60 pl.	...
24.8	Not stated.	56 pl.	...
16.6	Do.	50 pl.	...
40.000	47.000	92 pl.	40 pl.
30.000	35.000	78 pl.	30 pl.
18.900	Not stated.	48 pl.	...
19.900	...	60 pl.	...
21.800	...	60 pl.	...
20.300	23.8	40 pl.	...
33.200	38.2	50 pl.	...
39.000	Not stated.	50 pl.	...
34.000	Not stated.	65 pl.	20 pl.
32.000	Do.	76 pl.	34 pl.
18.500	Do.	43 pl.	24 pl.
45.000	Do.	65 pl.	17 pl.
19.500	Do.	40 pl.	22 pl.
23.000	29.000	57 { 12 1st cl. 45 3rd cl.	...
...	...	...	...
18.900	Not stated.	39 3rd. cl.	...
17.000	23.000	70 pl.	12 pl.

APPENDIX I. (*Continued.*)

ADMINISTRATIONS. 1		Number of axles and wheel base. 9	Method of driving. 10
			Light ra
Czechoslovakian State Railways		Not stated.	Central.
		Do.	1 cab.
		Do.	Do.
		Do.	2 cabs.
		Do.	Central.
		Do.	Central.
Jugoslavian State Railways		2 axles.	2 cabs.
Danish State Railways		Not stated.	1 cab.
Norwegian State Railways		2 axles, rear driving.	1 cab.
		Do.	Do.
National Light Railway Co. (Belgium)		2 axles. — 4.350 m. Rear axle driving, bogie at the front, wheel base: 4.150 m.	1 cab with turning device.
			Do.
Sud de l'Aisne Railways		2 axles.	1 cab.
Aube Departmental Railways		2 axles.	1 cab with turning device.
Do.	Meurthe-Moselle system	2 axles.	1 cab.
Indre Tramways		2 axles.	1 cab with turning device.
		Do.	Do.
		Do.	Do.
Deux-Sèvres Tramways		2 axles.	1 cab with special turning device.
Loiret Tramways		2 axles.	Do.
Nord-Est Secondary Railways		2 driving axles. 3.60 m.	2 cabs.
		Do.	Do.
		2 axles, rear driving 4.25 m.	1 cab with special turning device.
		2 driving axles, 3.00 m.	2 cabs.
Compagnie Générale de voies ferrées d'intérêt local.	Anvin-Calais line	2 axles, rear driving	2 cabs.
		2 driving axles.	Do.
Do.	Milly-Formeries line.	Do. Wheel base: 3.60 m.	Do.
Société de Transports en commun de la Région parisienne		2 driving axles, 3.60 m.	2 cabs.
Midi Railway Company (France)		2 axles. — 6.94 m.	1 cab.
Paris-Orléans Railway Company (Blan to Argent line)		2 driving axles. 3.600 m.	2 cabs.
French State Railways		Not stated.	1 cab. Turned on turntable of 5.250 m.

Engine. 11	Average consumption per 100 km. Fuel. 12	Lubricant. 13
motor cars.		
Tatra 6 cyl.	Not stated.	Not stated.
C. D. K. 4 cyl.	...	...
Skoda 4 cyl.	...	...
Tatra 6 cyl.	...	...
Do.	...	...
Do.	...	...
Not stated. 6 cyl., 90 H. P. at 1 250 r. p. m.	Petrol: 48.4 kgr.	Oil: 0.238 kgr. Grease: 0.0093 kgr.
100 H. P. at 2 000 r. p. m.	Not stated.	Not stated.
6 cyl., 120 H. P. at 1 650 r. p. m.	Petrol: 35 kgr.	0.95 kgr. approx.
6 cyl., 120 H. P. at 1 650 r. p. m. Auxil. engine, 80 H.P. at 1 900 r. p. m.	Petrol: 35 kgr.	0.95 kgr. approx.
4 cyl., 68 H. P. at 2 150 r. p. m.	Petrol: 31 l.	0.965 kgr.
4 cyl., 55 H. P. at 1 300 r. p. m.	Petrol: 45 l.	1.600 kgr.
4 cyl., 18 H. P.	National fuel: 25 l.	4.6 kgr.
4 cyl., 50 H. P. at 1 500 r. p. m.	Petrol: 26 l.	Not stated.
4 cyl., 25 H. P.	Petrol 26 l.	Oil 0.800 kgr.
4 cyl., 35 H. P.	Petrol 28 l.	Oil 0.900 kgr.
4 cyl. De Dion, 80 H. P.	Petrol: 35 l.	1 kgr. approx.
4 cyl. De Dion, 45 H. P.	Petrol: 25 l. Petrol: 22 l.	1 kgr. approx.
4 cyl. De Dion, 20 H. P.	Petrol: 27 l.	0.800 kgr. approx.
4 cyl. De Dion, 40 and 50 H. P.	Petrol: 30 l.	1 kgr.
4 cyl., 45 H. P. at 1 500 r. p. m.	Petrol: 45 l.	3 kgr.
4 cyl., 60 H. P. at 1 260 r. p. m.	Petrol: 46 to 70 l.	2 to 3.6 kgr.
4 cyl., 35 H. P. at 1 500 r. p. m.	Petrol: 28 l.	0.700 kgr.
4 cyl. Aster, 30 H.P. at 1 400 r. p. m.	Petrol: 33 to 37 l.	1 to 2 l.
4 cyl., 45 H. P. at 1 500 r. p. m.	Petrol: 30 l.	0.900 kgr. approx.
Do.	Petrol: 30 l.	0.900 kgr. approx.
Do.	Petrol: 29 l.	0.900 kgr. approx.
4 cyl., 60 H. P. at 1 250 r. p. m.	Petrol: 36 l.	2 kgr. approx.
Peugeot-Diesel 3 cyl., 70 H. P.	Gas-oil: 16 l.	...
4 cyl., 60 H. P. at 1 500 r. p. m.	Petrol: 31 to 35 l. Nabol: 28 to 29 l.	1 kgr.
6 cyl., 100 H. P. at 1 800 r. p. m.	Petrol: 41 l.	1.250 kgr.

APPENDIX I. (*Continued.*)

ADMINISTRATIONS.	Number of axles and wheel base.	Method of driving.
1	9	10
Do.	Not stated.	1 cab. Turned on turntable of 4.500 m.
Do. Pallet-Vallet line	2 axles.	1 cab. Turned on turntable.
Do. Vendée Tramways	Not stated.	Do.
		Heavy ra
Czechoslovakian State Railways	Not stated.	2 cabs.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
Danish State Railways	Not stated.	1 or 2 cabs.
	Do.	2 cabs.
Norwegian State Railways	2 bogie trucks.	2 cabs.
	2 axles.	Do.
Belgian National Railway Company	2 bogie trucks.	2 cabs.
	Not stated.	Do.
Rumanian State Railways	2 axles.	1 cab.
	Do	1 cab.
	Do	1 cab.
Finnish State Railways	2 axles, 1 driving, wheel base: 6.00 m.	2 cabs.
	2 bogie trucks—8.630 m.	Do.
Swedish State Railways	Not stated.	2 cabs.
Netherlands Railways	2 bogie trucks, 11.500 m.	2 cabs.
	Do.	Do.
	2 axles — 6.00 m.	Do.
	2 bogie trucks, 13.00 m.	Do.
	2 axles — 6.00 m.	Do.
Paris-Lyons-Mediterranean Railways	2 bogie trucks, 11.00 m.	2 cabs.
French State Railways	Not stated.	1 cab. Turned on turntable of 5.500 m.
Nord-Est Secondary Railways	2 bogie trucks, 12.92 m.	2 cabs.

APPENDIX I. (*Continued.*)

Engine. 11	Average consumption per 100 km. Fuel. 12	Lubricant. 13
4 cyl., 85 H. P. at 1 300 r. p. m.	Petrol: 59 l.	2.100 kgr.
6 cyl., 80 H. P. at 1 500 r. p. m.	Petrol: 80 l.	4 l.
4 cyl., 45 H. P. at 1 500 r. p. m.	Petrol: 30 l.	1.500 l.
otor cars.		
Tatra 6 cyl., 100 H.P. at 1 200 r. p. m.	Not stated.	Not stated.
D. W. 6 cyl., 150 H. P. at 1 000 r. p. m.	Do.	Do.
Daimler 4 cyl., 2×60 H. P. at 1 200 r. p. m.	Do.	Do.
M. A. G. 6 cyl., 2×75 H. P. at 1 050 r. p. m.	Do.	Do.
Do.	Do.	Do.
Tatra 6 cyl., 2×100 H. P. at 1 200 r. p. m.	Do.	Do.
Do.	Do.	Do.
Do.	Do.	Do.
Do.	Do.	Do.
Gräft and Stift 6 cyl., 2×100 H. P. at 1 950 r. p. m.	Do.	Do.
Do.	Do.	Do.
Tatra 6 cyl., 100 H.P. at 1 200 r. p. m.	Do.	Do.
Brno 6 cyl., 100 H. P. at 1 500 r. p. m.	Do.	Do.
100 to 140 H. P.	Not stated.	Not stated.
180 H. P. at 900 r. p. m. (Diesel engine).	Do.	Do.
160 H. P. at 1 320 r. p. m.	Petrol: 38 kgr.	0.950 kgr.
75 H. P. at 950 r. p. m.	Petrol: 38 kgr. (approx.).	0.950 kgr.
Diesel 6 cyl., 150 H.P. at 1 350 r. p. m.	Gas-oil: 42 l.	1.5 to 2 kgr.
Steam, 2-stroke. Single acting, 100 H.P. at 600 r. p. m. 6 horizontal cylinders.	Coal: 350 kgr.	1.5 kgr.
60 H. P. / 70 H. P. / 90 H. P. coupled with compound dynamo.	65 kgr.	0.650 kgr.
A. E. G. 6 cyl., 75 H. P.	Not stated.	Not stated.
Diesel 6 cyl., 90 H. P. at 600 r. p. m.	Do.	Do.
Diesel-electric, 90 H. P.	Not stated.	Not stated.
N. A. G., 2×75 H. P.	Petrol: 81 kgr.	2.1 kgr.
Do.	66 kgr.	1.6 kgr.
Man-Diesel.	Gas-oil: 25.7 l.	2.6 kgr.
D. W., 2×115 H. P.	Petrol: 100 kgr.	2.6 kgr.
100 H. P.	Petrol: 53.5 kgr.	2.0 kgr.
6 cyl., 110 H. P. at 2 200 r. p. m.	Not stated.	Not stated.
6 cyl., 94 H. P. at 1 800 r. p. m.	Charcoal: 120 kgr. Petrol: 17 l.	2.650 kgr.
6 cyl., 110 H. P. at 2 200 r. p. m.	Petrol: 88 to 91 l.	3.5 to 5.3 kgr.

APPENDIX I. (*Continued.*)

ADMINISTRATIONS. 1	Change speed gear. 14	Transmission. 15
		Light rai
Czechoslovakian State Railways	By hand. By hand. By hand. By hand. By hand. By hand.	Mechanical. Mechanical. Mechanical. Mechanical. Mechanical. Mechanical.
Jugoslavian State Railways	By hand.	Mechanical. 1 driving axle.
Danish State Railways	By hand.	Mechanical.
Norwegian State Railways	By hand. By hand.	Mechanical. Mechanical.
Belgian National Light Railway Co.	By hand. By hand.	Mechanical. Mechanical.
Sud de l'Aisne Railways	By hand.	Mechanical.
Aube Departmental Railways	By hand.	Mechanical.
Do. Meurthe-Moselle system	By hand.	Mechanical.
Indre Tramways	By hand.	Mechanical.
Deux-Sèvres Tramways	By hand.	Mechanical.
Loiret Tramways	By hand.	Mechanical.
Nord-Est Secondary Railways	By hand. By hand. By hand. By hand.	Mechanical. Mechanical. Mechanical. Electrical. 2 engines 10 kw.
Compagnie Générale de voies ferrées d'intérêt local. Anvin-Calais line	By hand. By hand.	Mechanical. Mechanical.
Do. Milly-Formeries line.	By hand.	Mechanical.
Société de Transports en commun de la Région parisienne	By hand.	Mechanical.
Midi Railway Company (France)	By hand.	Mechanical.
Paris-Orleans Railway Company (Blan to Argent line)	By hand.	Mechanical.

Brake.	Remarks.
16	17
…otor cars.	
Hand brake. Do. Do. Do. Do. Do.	1 vehicle provided in 1928. Do. 1927. Do. 1927. Do. 1928. Do. 1928. Do. 1930.
Compressed air. Hand brake.	Clutch operated by compressed air.
Compressed air.	This type of vehicle has only one driver's cab, but the vehicles are coupled in pairs.
Hand brake. Carpenter brake.	Dead man's handle. Do.
Hand brake. Vacuum brake.	The auxiliary engine is rubber suspended below the frame at the end of the rear axle.
Hand brake. Do.	Front wheels adjustable to curves. …
Hand brake.	…
Hand brake. Do.	… Turning by means of turntable.
Hand brake.	Emergency lighting by acetylene.
Hand brake.	In the most recent types, the wheels are inside the frame.
Hand brake.	Emergency brake within reach of the passengers.
Hand brake. Compressed air.	… …
Do. Do. Do.	… Run with 2 and 3 trailers on the level.
Hand brake. Do. Do.	The reduced petrol consumptions for the same types R. S. 2 are due to change of carburettor.
Hand brake. Compressed air.	Special provision for running with one employee. 46 l. per 100 km. with trailer.
Hand brake.	Under test. The 20 passengers standing may be replaced by 2 000 kgr. of luggage.
Hand brake. Compressed air.	Portable telephone in case of breakdown in open line.

APPENDIX I. (*Continued.*)

ADMINISTRATIONS. 1	Change speed gear. 14	Transmission. 15
French State Railways	By hand.	Mechanical.
Do.	By hand.	Do.
Do. Pallet-Vallet line	Do.	Do.
Do. Vendée Tramways	Do.	Do.
		Heavy ra
Czechoslovakian State Railways	By hand.	Mechanical.
	Do.	Do.
	Compressed oil.	Mech. (Winterthur).
	Compressed air.	Do. (N. A. G.).
	Do.	Do.
	Do.	Mech. (Winterthur).
	Do.	Do.
	Do.	Electrical (Gebus).
	Do.	Mechanical.
	Do.	Electrical (Gebus).
	Do.	Do.
	Do.	Do.
	Do.	Elect. (Brown-Boveri).
Danish State Railways	Not stated.	Mechan. or electr.
	Do.	Electrical.
Norwegian State Railways	By hand.	Mechanical.
	Do.	Do.
Belgian National Railway Company	By hand. 4 groups remaining in mesh.	Mechanical.
	...	...
Rumanian State Railways	...	Electrical. Tens. 500 and 550 volt
Finnish State Railways	By hand.	Mechanical.
	...	Electrical.
Swedish State Railways	...	Electrical.
Netherlands Railways	By hand.	Mechanical.
	Do.	Do.
	Do.	Do.
	Do.	Do.
	Do.	Do.
Paris-Lyons-Mediterranean Railways	By hand.	Mechanical.
	...	...
French State Railways	By hand.	Mechanical.
Nord-Est Secondary Railways	By hand.	Mechanical.

Brake. 16	Remarks. 17
Servo brake.	On these vehicles, the original petrol engine is being replaced by heavy oil engine. — 19 l. gas oil.
Hand brake.	
Compressed air.	Vehicles resulting from the conversion of old pattern vehicles.
Hand brake.	
Do.	
Hand brake.	
otor cars.	
Compressed air.	The original engine was a Mercedes aircraft engine.
Do.	...
Do.	...
Do.	...
Do.	...
Do.	...
Do.	...
Do.	...
Do.	Transmission by Planet gear.
Do.	...
Do.	...
Do.	...
Do.	The Diesel engine is to be tried.
Compressed air.	...
Do.	...
Hand brake.	Axles with free radial adjustment.
Vacuum brake.	Anti-rolling device.
Do.	
Compressed air.	Hydraulically operated friction clutch.
Vacuum, direct.	Water-tube boiler — 1 000 l. per hour — working pressure 21 kgr. per sq. cm.; superheat: 380° C.
Not stated.	The gear ratios of the motor pinions are 1/3 and 1/3.5 for the 90-H. P. vehicle.
Hand brake. Compressed air.	Engine coupled directly to a generator supplying 2 traction motors.
Compressed air.	...
Compressed air.	...
Do.	...
Do.	...
Do.	..
Do.	...
Hand brake.	Isothermos boxes.
Compressed air.	
...	This stock will shortly cease to exist.
Hand brake. Compressed air.	Has only run 4 000 km. since it was put in service in June 1929. Standing since 1929 for damage to engine.
Hand brake.	...

APPENDIX II.

Table summarising the conditions under whi

ADMINISTRATIONS.		Type defined in Appendix I.	Gauge (in metres).	Maximum gradients (in mm. per m.
1		2	3	4
				Light rai
Czechoslovakian State Railways		11-0 120-0 120-1 120-2 120-3 120-4	0-760 1.435 Do. Do. Do. Do.	26.8 33 Do. Do. Do. Do.
Jugoslavian State Railways		A.	1.435	5
Danish State Railways		M. A.	1.435	10
Norwegian State Railways		A. B.	1.067 1.435	25 Do.
Belgian National Light Railways Co.		A.	1.00	35
		B.	1.00	35
Sud de l'Aisne Railways		A.	1.00	35
Aube Departmental Railways		J. M.	1.00	15
Do.	Meurthe-Moselle system	J. A.	1.00	30
Indre Tramways		Kg²	1.00	45
		J. M., type « Deux-Sèvres ».	1.00 1.00	0.65 ...
Deux-Sèvres Tramways		A.	1.00	54
Loiret Tramways		A.	1.00	35
Nord-Est Secondary Railways		R. S. 2 R. S. 4 J. M. 2 C. L.	1.00 1.00 1.00 0.60	25 25 20 18
Compagnie Générale de voies ferrées d'intérêt local.	Anvin-Calais line	R. S. 1 R. S. 2	1.00 1.00	15 15
Do.	Milly-Formeries line.	R. S. 2	1.00	15

e various types of rail motor cars are used.

Minimum curves (in metres). 5	Total number of places. 6	Compartments (area or dimensions). Luggage. 7	Post. 8	Trailer. 9
otor cars.				
75	32 3rd class.	Lacking in most cases.	Nil.	Trailers anticipated (no exact information).
150	31 Do.		Do.	
Do.	31 Do.		Do.	
Do.	32 Do.		Do.	
Do.	38 Do.		Do.	
Do.	46 Do.		Do.	
250	15 2nd class. 31 3rd class.	Exists.	Nil.	All vehicles run with a trailer.
150	24 3rd class.	In common with the driver's cab.	Nil.	Light 2-axle trailers.
100	24 3rd class.	Exists.	Nil	Light trailers.
180	42 3rd class.	Do.	Nil.	Axles with roller bearings.
25	29	In common with driver's.	Nil.	No trailer.
25	25	Do.	Nil.	
35	30	Nil.	Nil.	Ordinary trailers.
150	35	In common with driver's cab.	Nil.	Special trailers with Bissel bogies.
25	20	Do. (1m²).		Light type (1 200 kgr.).
27.75	42	Exists.	Exists.	One or two trailers of 3.5 tons empty.
	26	Nil.	Nil.	1 trailer of the preceding type.
	30	Nil.	Nil.	One 1.5-ton trailer. (20 passengers or 2 000 kgr. of luggage).
30	34	Nil (In trailer).	40 cm. × 60 cm. at rear.	Special 2-wheel type: Tare: 600 kgr. Load: 1 500 kgr.
60	30	Nil.	Common with driver's cab.	Special type: 1 200 kgr. empty; 12 places seated; 12 places standing.
50	40	2.75 m²	Exists.	Ordinary passenger coaches.
50	40	Do.	Do.	Do.
60	34	Do.	Do.	Do.
30	32	Nil.	Nil.	Do.
100	40	2.75 m²	Exists.	Small passenger coaches, 5 tons, 2 axles.
100	40	Do.	Do.	
100	40	Do.	Do.	24 places.

APPENDIX II. (*Continued.*)

ADMINISTRATIONS. 1	Type defined in Appendix I. 2	Gauge (in metres). 3	Maximum gradients (in mm. per m.) 4
Société de Transports en commun de la Région parisienne.	R. S. 4	1.44	25
Midi Railway Company (France)	A.	1.44	Not stated.
Paris-Orleans Railway Company (metre gauge, (Blan to Argent line).	R. S. 4	1.44	15
French State Railways	Renault. Schneider.	1.44 1.44	16.3 16.3
Do. Pallet-Vallet line	Not stated.	1.44	14.7
Do. Vendée Tramways	Renault.	1.00	15.4
			Heavy rai
Czechoslovakian State Railways	210.0 to 221.1	1.435	33
Danish State Railways	M.C., M.E., M.F., M.L., M.R. (Diesel)	1.435 1.435	10 10
Norwegian State Railways	D. W. and A. E. G.	1.435	10
Belgian National Railway Company	Maybach (Diesel).	1.435 1.435	8 and 5 9.7 and 6
Rumanian State Railways	A. B. C.	1.435 1.435 1.435	18
Finnish State Railways	A. B.	1.524 1.524	11.5
Swedish State Railways	A.	1.435	16
Netherlands Railways	C. 911—16 to B. C. 1901—3.	1.435	13
Paris-Lyons-Mediterranean Railway Company .	Renault.	1.44	Not stated.
French State Railways	Producer gas (Renault).	1.44	16.6
Nord-Est Secondary Railways	Renault-Scemia. P. S.	1.44	14

inimum curves (in metres). 5	Total number of places. 6	Compartments (area or dimensions). Luggage. 7	Post. 8	Trailer. 9
50	32 { 7—1st cl. 25—2nd cl.	3 m²	Nil.	Small passenger coaches. 7.3 tons (16 places seated; 16 standing).
Not stated.	61	Exists.	Nil.	No trailer.
150	40	Nil.	Common with driver's cab.	2 axles, 14 places seated. 16 places standing. Air brake. No heating.
88	34 { 10—1st cl. 24—2nd cl.	Nil.	Nil.	No trailer.
88	20	Exists.	Do.	Railway type; 7 to 10 tons.
500	50	Do.	Common with driver's cab.	Do.
50	35	Do.	Do.	Ordinary coach.
otor cars.				
150	43 to 83 pl.	Nil.	Nil.	Not often used.
150	33, 33, 50, 70	Exists.	Nil.	Light, 2 axles.
150	60	Common with driver's cab.	Nil.	Do.
150	56 and 50	The rear driver's cab is used for luggage.	Nil.	Ordinary 2-axle cars, with roller bearings.
500 and 260	132	Nil.	Nil.	No trailer.
170 and 85	108	Do.	Nil.	
200	48	Nil.	Nil.	Special type.
	60	Do.	Nil.	
	60	Do.	Nil.	
300	40	Nil.	Nil.	Ordinary coaches.
	50	Exists.	Nil.	
300	50	Exists (3 tons).	Nil.	Ordinary coaches.
120	40 to 76	Common with driver's cab.	Nil.	Ordinary coaches.
Not stated.	57 { 12—1st cl. 45—2nd cl.	6 m²	Nil.	Nil.
300	39	Exists.	Nil.	7 to 10-ton railway type.
200	82	2.75 m².	Exists.	Small ordinary coach.

ADMINISTRATIONS. 1	Speed (in kilometres). 10	Staff. 11
		Light rail
Czechoslovakian State Railways	Normal: 45. Maximum: 60. Do. Do. Do. Do. Do.	1 driver. 1 guard. Do. Do. Do. Do. Do.
Jugoslavian State Railways	With and without trailer: 55 Commercial: 36.	1 driver. 2 train men.
Danish State Railways	Maximum: 74.	1 man.
Norwegian State Railways	55 } Commercial: 30 to 40. 65 }	1 man. 2 men.
Belgian National Light Railway Co.	Max.: 48. Comm.: 30. Do. 40. Do. 28.	2 men.
Sud de l'Aisne Railways	Maximum: 40. Commercial: 25.	1 or 2 men, according to traffic.
Aube Departmental Railways	Maximum: 40. On gradients 1 in 33: 20.	1 or 2 men.
Do. Meurthe-Moselle system	Max.: 40; Comm.: 22.	Do.
Indre Tramways	With trailer: 45.	2 men. ... ...
Deux-Sèvres Tramways	With or without trailer: Maximum: 45 to 50. Commercial: 25 to 30.	2 men.
Loiret Tramways	With or without trailer: Maximum: 40. Commercial: 30.	1 man. 2 men with trailer.
Nord-Est Secondary Railways	Maximum: 60. Commercial: 30. Maximum: 60. ...	2 men. Do. Do. Do.
Compagnie Générale de voies ferrées d'intérêt local: Anvin-Calais line	Maximum: 50. Commercial: 30 to 35.	2 men.
Do. Milly-Formeries line.	.	...
Société de Transports en commun de la Région parisienne	Maximum: 50. Commercial: 40.	2 men.

APPENDIX II. (*Continued.*)

Distance run annually (in kilometres). 12	Steps taken for repairs. 13	Number of days out of service per annum. 14
or cars.		
35 000 to 60 000	Monthly repairs (by the driver). Quarterly repairs (by the depot of the vehicle). Main repairs (by the workshops). Principal overhaul is done after 50 000 km. It may be postponed to 100 000 km.	100 days on the average.
51 000 to 69 000	No rule made yet (insufficient experience).	84 to 120 days.
80 000 to 85 000	Periodical overhauls (Duration: 10 days).	...
48 000 61 000	Periodical inspections. (Overhaul after 120 000 km.).	...
50 000	Periodical inspections. (Overhaul after 60 000 km.).	...
36 000	Only in case of unsatisfactory running.	12 days.
35 000	As needed.	90 days (approx.)
20 000 to 30 000		Varying
35 000	After 25 000 km.	...
33 000	As needed.	...
40 000	General inspection after 20 000 km.	125 days.
12 000 to 18 000	After 20 000 km.	100 days on the average.
24 000 21 000	Yearly overhaul.	Nil in 1930. 50 days on the average.
10 000 to 12 000	Periodical inspections.	50 to 60 days.
15 000	General overhaul after 50 000 km.	...
20 000 (approx.)	Periodical inspections. General overhaul after 60 000 km. (Duration: 20 days).	...

APPENDIX II. (*Continued.*)

ADMINISTRATIONS. 1	Speed (in kilometres). 10	Staff. 11
Midi Railway Company (France)	Maximum: 80. On gradients 1 in 67: 60. Do. 1 in 30: 40.	2 men.
Paris-Orleans Railway Company (metre gauge), (Blan to Argent line).	Maximum: 50. Commercial: 38.	1 man.
French State Railways	Maximum: 90. Gradients 1 in 50: 65.	2 men.
	Without trailer: 70. With trailer: 55.	Do.
Do. Pallet-Vallet line	With trailer: 30.	Do.
Do. Vendée Tramways	With trailer: 35. Commercial: 25.	Do.
		Heavy ra
Czechoslovakian State Railways	Maximum: 80.	2 men.
Danish State Railways	Maximum: 74. Maximum: 80.	1 man. Do.
Norwegian State Railways	Maximum: 65.	1 or 2 men.
Belgian National Railway Company	Max.: 65; Comm.: 40. Max.: 85; Comm.: 40.	2 men. 3 men.
Rumanian State Railways	Maximum: 45. Maximum: 50. Maximum: 65. Commercial: 35/40.	2 men.
Finnish State Railways	40/44. 44/56.	2 men.
Swedish State Railways	60.	2 men.
Netherlands Railways	54 to 70.	1 man.
Paris-Lyons-Mediterranean Railway Company	....	2 men.
French State Railways	Maximum: 65. With trailer: 50.	2 men.
Nord-Est Secondary Railways	Without trailer: Maximum: 78. Commercial: 30.	2 men.

APPENDIX II. (*Continued.*)

Distance run annually (in kilometres). 12	Steps taken for repairs. 13	Number of days out of service per annum. 14
...	...	...
41 700	According to requirements. Daily inspection.	82 days.
95 000 (expected).	After 110 000 km.	...
30 000	After 35 000 km.	115 days.
12 000	According to requirements.	20 days.
30 000	Do.	15 to 20 days.
otor cars.		
35 000 to 60 000	Same rules as for light rail motor cars.	100 days on the average.
80 000 to 85 000	After 50 000 km. (10 days). After 50 000 km. (3 weeks).	...
61 000 approx.	Periodical inspections. (Overhaul after 120 000 km.).	...
83 220 67 160	Light overhaul: 35 000 km. Main overhaul: 100 000 km.	73 days. Nil.
40 000 to 50 000	Every three months: 8 days. Every year: 2 to 3 weeks. Every 3 or 4 years: 1 to 2 months.	...
38 000 to 50 000 45 000 to 50 000	General overhaul every other year.	72 days.
80 000 to 100 000	General overhaul after 80 000 km.	20 to 30 days.
51 000 approx.	2-axle vehicle: 60 000 km. 4-axle vehicle: 90 000 to 120 000 km.	49 days.
...	...	...
...	...	...
...	To workshops after 2 000 km.	...

APPENDIX II. (*Continued.*)

ADMINISTRATIONS. 1	Principal breakdowns. 15	Remarks. 16
	Light rail motor cars.	
Czechoslovakian State Railways	Engines and transmission gears.	Engine readily removable.
Jugoslavian State Railways	Cracked castings. Transmission gear. Fract. of storage battery plates.	Special type of trailer with roller be ings and similar contruction to t motor car.
Danish State Railways	...	Engine readily removable.
Norwegian State Railways	Trouble with accessories and fuel supply.	Engine readily removable (2 to 3 days
National Light Railway Co. (Belgium) . . .	Troubles similar to those met with on automobiles.	Sometimes one employee only. Conductor is taught to drive.
Sud de l'Aisne Railways	Fracture of the ball bearings of the wheels.	...
Aube Departmental Railways . . . . Do. Méurthe-Moselle system .	Normal wear. Trouble with accessories.	The 2nd employee is sometimes capa of replacing the driver.
Indre Tramways	Pistons, valves and anti-friction bearings.	The trailer can carry 2 000 kgr. of luggage and 20 passengers.
Deux-Sèvres Tramways	...	...
Loiret Tramways	Secondary shafts of speed boxes.	...
Nord-Est Secondary Railways	Transmission. ... Ball bearings of the traction motors.	Power of engine too low. Have run 55 000 km. without repairs Run with 2 or 3 trailers on the level
Compagnie Générale de voies ferrées d'intérêt local. } Anvin-Calais line . . Do. Milly-Formeries line.	Dynastart transmission.	...
Société de Transports en commun de la Région parisienne	...	1 employee only since January 1931. The necessary modifications have bee made.
Midi Railway Company (France)	...	Under test.

APPENDIX II. (*Continued.*)

ADMINISTRATIONS. 1	Principal breakdowns. 15	Remarks. 16
s-Orleans Railway Company (metre gauge), lan to Argent line).	Cylinders, crankshaft bearings.	...
ch State Railways	No breakdowns.	Service just beginning.
Do. Pallet-Vallet line	Do.	
Do. Vendée Tramways	Do.	
	Heavy rail motor cars.	
hoslovakian State Railways	Engines and transmission.	Engines readily removable.
ish State Railways	Compressors.	The mileage will be increased to 60 000 km. before overhauling.
wegian State Railways	Fuel supply and accessories.	...
gian National Railway Company . . .	Compressor valves Water gauge tubes.	Theoretical length of run: 103 660 km. Do. 69 350 km.
nanian State Railways	Suspension and axles.	...
nish State Railways	...	...
dish State Railways	...	Engine replaced in one day.
herlands Railways	Gears-Diesel: engines, pistons, abnormal oil consumption.	Trailers used in summer only.
is-Lyons-Mediterranean Railway Company .	...	...
nch State Railways	...	Breakdown after 4 000 km.
d-Est Secondary Railways	Engine power insufficient resulting in breakdowns.	...

Table summarising the results from the finan

(The figures given have been reduced to French francs or

ADMINISTRATIONS.	Type as defined in Appendix I.	Gauge (in metres).	Fuel.	Lubrica
				Light
Czechoslovakian State Railways	11-0 to 120-4	0.760 (Type 11-0) 1.425	0.896	0.10
Jugoslavian State Railways	A.	1.435	1.863	
Danish State Railways	M. A.	1.435	Not stated.	
Norwegian State Railways	A. B.	1.067 1.435	0.500 0.686	
Belgian National Light Railways Co	A. B.	1.000 1.000	1.332 1.913	
Sud de l'Aisne Railways	A.	1.000	0.296	
Aube Departmental Railways	J. M.	1.000	0.648	0.036
Do. Meurthe-Moselle system .	J. A.	1.000	0.70	
Indre Tramways	K. G. 2-J. M. « Deux-Sèvres ».	1.000	0.950	
Deux-Sèvres Tramways	A.	1.000	0.325	
Loiret Tramways	A.	1.000	...	0.745
Nord-Est Secondary Railways	R. S. 2	1.000	0.960	0.170
	R. S. 4 J. M. 2 C. L.	1.000 1.000 0.60	1.160 0.620 0.780	0.115 0.04 0.07
Compagnie Générale de voies ferrées d'intérêt local. Anvin-Calais line . .	R. S. 1 R. S. 2	1.000 1.000	0.635 0.605	0.092 0.101
Do. Milly-Formeries line.	R. S. 2	1.000	0.659	0.139
Société de Transports en commun de la Région parisienne	R. S. 4	1.440	Not stated.	
Paris - Orleans Railway Company (Blan to Argent line)	R. S. 4	1.000	0.660	0.060
French State Railways	Renault.	1.440	1.70	
Do.	Schneider.	1.440	1.72	
Do. Pallet-Vallet line	Not stated.	1.440	1.80	0.25
Do. Vendée Tramways	Renault.	1.000	0.660	0.08

APPENDIX III.

oint of view (cost per train-kilometre).

asis of the rate of exchange of 24th January, 1932.)

Maintenance nd miscellaneous.	Staff.	Total.	Remarks.
otor cars.			
1.232	0.252	2.485	6 years' experience (75 vehicles). These figures relate to 1930. The cost of staff is based on 1 employee whereas there are 2 employees per vehicle.
0.612	0.455	2.93	These figures correspond to 2 1/2 years' experience.
Not stated.	Not stated.	Not stated.	...
0.498	0.760	1.758	The cost of staff includes cleaning.
0.834	0.760	2.280	4 years' experience.
0.085	0.425	1.842	3 months' experience.
0.340	0.531	2.784	Several years' experience.
0.20	0.550	1.046	9 years' experience.
0.205	0.330	1.219	4 years' experience } Figures relating to 1930.
0.500	0.300	1.500	5 years' experience } Figures relating to 1930.
0.400	0.500	1.850	More than 4 years' experience.
0.430	0.520	1.275	9 years' experience.
...	0.3555	1.1013	7 years' experience up to 1.1.31. Cost reduced to 1.0294 fr. since this date by partly dispensing with one employee.
2.30	1.78	5.21	6 years' experience. } Service of a special nature crossing Soissons (37.5 km. daily).
0.233	0.853	2.361	About 3 years' experience. } The figure relate to 1930.
0.050	0.690	1.400	2 years' do.
0.28	0.540	1.670	6 years' do.
0.657	0.410	1.794	7 years' experience } The figures given represent the average on 1.1.31.
0.535	0.410	1.651	6 years' experience.
0.537	0.404	1.739	6 years' experience.
0.750	Not stated.	Not stated.	6 years' experience.
0.540	0.440	1.70	About 6 years' experience.
New stock.	0.720	2.42 } amortization included.	6 months' experience. } The substitution of Diesel engines in place of the present engines reduces the cost to 1.73 fr.
0.530	1.300	3.55 } amortization included.	7 years' experience.
0.800	2.000	4.85	6 years' experience.
0.650	0.900	2.29	7 years' experience.

APPENDIX III. (*Continued.*)

ADMINISTRATIONS.	Type as defined in Appendix I.	Gauge (in metres).	Fuel.	Lubricatic
				Heavy ra
Czechoslovakian State Railways	220-0 to 221-1	1.435	0.896	0.105
Danish State Railways	...	...	...	...
Norwegian State Railways	D. W. and A. E. G.	1.435	0.686	
Belgian National Railway Company	Diesel « Maybach ». Sentinel.	1.435 1.435	0.177 0.475	0.0495 0.0567
Rumanian State Railways	A. B. C.	1.435	0.326	0.043
Finnish State Railways	A. B.	1.524 1.524	0.748 0.123	
Swedish State Railways	A.	1.435	...	...
Netherlands Railways	B. C. 1901-1903, C. 1901-1910, C. 901-908, B. C. 1904-1910, C. 911-916	1.435	0.891	
French State Railways	Renault (producer gas).	1.440	...	...
Nord-Est Secondary Railways	Renault-Scemia, P. S.	1.440	1.812	1.812

APPENDIX III. (*Continued.*)

…enance …ellaneous.	Staff.	Total.	Remarks.
…ars.			
232	0.252	2.485	Same figures as for the light motor cars, this Administration having given a general average.
..	...	...	Not stated.
834	0.760	2.280	Same figures as for the type B light motor cars, this Administration having given a general average.
383	0.560	1.169	About 1 year's experience.
272	1.290	2.093	Do.
063	0.455	1.887	...
1.338		2.086	...
1.3325		1.4555	...
3395	...	Between 0.972 and 1.2125	7 years' experience.
154	0.627	2.672	...
42	1.30	6.92	Including amortization. 18 months' experience. Vehicles under repair.
955	1.016	3.981	Figures for the financial year 1930. About 2 years' experience.

[621 . 151.3]

New plants, apparatus and methods for carrying out scientific investigations on locomotives and their component parts,

by Dipl.-Ing. KARL GÜNTHER, Reichsbahnrat, Potsdam,

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General. — Equipment of locomotive testing department: Schenck weighing machine. Testing boiler. Testing apparatus for stuffing boxes, lighting turbines, pumps and injectors, oil pumps and oil valves. Testing machine for measuring the radial pressure exerted by piston rings. Machine for testing wear. Auxiliary testing equipments. Dynamometer cars.

New methods of testing locomotives: Work preparatory to tests. Braking locomotives. Selection of test track. Experimental methods. Carrying out the tests and making use of the results.

Experimental stations for locomotives and rail motor vehicles: Introductory notes. — Layout of buildings. — Method of bringing locomotives into position. — Braking equipment. — Sanding equipment. — Apparatus for ensuring true verticality. — Crane. — Smoke removal. — Separation of ashes and flue dust. — Coaling. — Feed water supply and ash removal. — Measuring equipment.

Although the locomotive is now more than a hundred years old, its development has not yet reached finality, and efforts are constantly being made to improve it. The endeavour to obtain more economical designs has led to entirely new lines of development, and, in the past ten years more particularly, a considerable number of novel features have been introduced : A greater range of pressure drop has been utilised by the introduction of high-pressure locomotives and condensing turbine locomotives. Firing has been improved by the use of powdered fuel and other types of heat engine have been tried, as in the case of the Diesel locomotive.

Every improvement necessitates the modification of many parts which have not yet been thoroughly tried out in their new form. Even with the older designs of locomotive there are many combinations and alternative arrangements that have not yet been fully investigated, and thorough tests are still more important in the case of designs that incorporate features of an entirely novel character.

Experience is practically the only guide when working out new designs of engines or components, and since the older designs represent a great number of compromises, it is not easy to combine with relative proportions that have been found to give the best results, improved fuel economy and greater-operating safety, and the lowest repair costs.

Research is necessary both to determine the economy of old locomotives and the effect of introducing improvements, and also to investigate new designs of locomotives and components;

such research will enable further development to be carried out along sound lines.

At one time experimental work of this kind was carried out in a more or less irregular manner by the individual Divisions of the German Railways, but there was no co-ordinated programme, and above all the results were not collated. It was not until the forming of the Central Railway Bureau, in 1907, and the transfer of locomotive design from the Prussian railways to the Bureau that the latter took over the research branch. Since that time the Central Bureau has supervised all experimental work on locomotives, has collected the results, and made use of them for the improvement of design of the various types of locomotive. The results are published which, besides stimulating industry, enables improvements to be made in locomotive operation.

Even before the war, the scope of the research work had grown to such an extent that it was necessary to set up a special locomotive research board (Dezernat) in the Central Railway Bureau. The experimental work was then divided into two classes which are still retained, namely, running tests undertaken by the railway managements in order to obtain results under service conditions, and scientific tets for which special apparatus is necessary. After the war it was found that the volume of scientific work could not be dealt with by the head of the special board (Dezernent) and his assistant, and on 1 April 1920, a special department was instituted which subsequently became the Locomotive Research Department at the Grunewald Works.

The building up of this department to a stage where it can undertake scientific research work has now reached a certain measure of completeness, and the equipment and methods of measurement are described in the present article.

Equipment of the research department for scientific investigations on locomotives.

The Locomotive Research Department with its equipment was installed in the shops of the former Locomotive Repair Department, Grunewald Workshops. By providing a turntable 23 m. (75 ft. 5 in.) long outside, supplied by the *Siegener Maschinenfabrik*, is was possible to utilise the accommodation in the old locomotive shed for the longest locomotives. The greater part of this accommodation is used for preparing locomotives for test runs and for housing the dynamometer cars. The existence of a central smoke hood in the firing-up shed and the fact

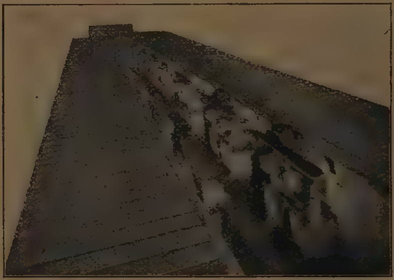

Fig. 1. — Schenck weighing machine.

that sufficient length of track is available enables this section to be used for making up the test trains on the day before the test; all electrical connections are made and tested and every detail of the preparations completed.

It is important to determine accurately the weight of the locomotive and the weight distribution on the individual axles. For this purpose a Schenk weighing machine of fourteen sections was installed, each section having a capacity of 12.5 tons and it is thus possible to weigh a seven-axle engine having an axle load of 25 tons; the machine is illustrated in figure 1.

For the purpose of checking the accuracy of the individual sections of the weighing machine at any time, and to revise them annually a special calibrating device has been purchased, figure 2. This apparatus is used, also, for calibrating the Schenck machines belonging to the repair shops.

In order to provide a constant supply of steam at the usual pressures and temperatures a water-tube boiler (supplied by the *Hanomag*, of Hanover-Linden) has been installed. This unit has a heating surface of 90 m² (969 sq. feet) and can supply steam up to 20 atm. (284.5 lb. per sq. inch) and 400° C. (752° F.). It is fitted with forced draught so that its output can be increased quickly when required. All the testing devices on which steam is required are in proximity to the boiler and can be connected up to it by short lengths of pipe.

Fig. 2. — Calibrating device for Schenck weighing machine.

The stuffing boxes of locomotive piston rods had been a source of much trouble to the management for a long time, especially since the war, and therefore a special equipment was put down for testing packings. This is now used only for testing the packings of locomotives using saturated steam, the grey cast iron packing boxes introduced for use with superheated steam having given excellent results.

The equipment shown in figure 3 consists of an old engine cylinder which can be supplied with steam at any desired pressure, and a piston rod coupled to a crank that is belt driven by an electric motor. The glands are packed with the particular packing it is desired to test, and records are kept of the life in hours, the time expended in tightening, loosening, fitting, etc., as well as of the power taken by the motor; the latter provides comparative figures for the gland friction. From the figures thus obtained and cost of the packing material used, it is possible to form an estimate of the economy of the various types tested.

Fig. 3. — Equipment for testing stuffing boxes.

Owing to its greater safety electricity is steadily replacing gas for lighting railway vehicles, and a generator carried on the locomotive is being used more and more as the source of supply. It has consequently become important to carry out proper tests on these turbo-generators, with a view to determining their life, the wear of the various parts and the steam consumption. A special equipment which permits four of these units to be tested simultaneously is shown in figure 4. To keep the conditions as uniform as possible and thus facilitate comparative tests, the steam is taken from a

feed pipe fitted with throttle and separator calorimeter so that the saturation degree can be ascertained. The pressures at the stop valve and nozzle are determined by manometers. The consumption of steam is ascertained by weighing it after it has been condensed in a separate condenser for each turbine. The current generated by the dynamo is measured and absorbed in an adjustable bank of lamps; a recording voltmeter is used since it is important to check that the pressure remains practically constant in spite of variations in steam pressure or load. A comparison between the brilliance of the lamps and that of a lamp connected to the ordinary supply is made in a dark room.

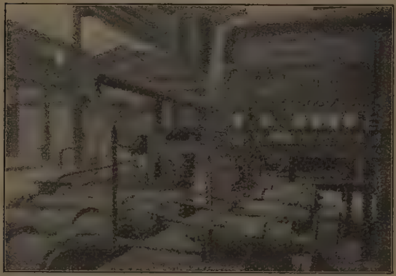

Fig. 4. — Equipment for testing turbo-electric generators for train lighting.

Fig. 5. — Feed-water pump and injector testing equipment.

It is of very special importance to test the reliability, capacity and economy of feed water pumps and injectors used for supplying water to locomotive boilers, particularly in view of the fact that these auxiliaries are usually inaccessible during running. The equipment shown in figure 5 has been installed for testing these components, with pipework, preheater and boiler feed valve, so that the conditions present in various classes of locomotives can be reproduced as nearly as possible. Steam is supplied by the stationary boiler already referred to and the pressure and temperature can be regulated as required; it is either slightly superheated or its moisture is checked by a throttle and separator calorimeter in order to determine its exact condition before using it. In the case of piston pumps the steam is condensed in an old locomotive preheater and weighed after passing through the pumps; it is measured, before entering the injectors, by means of a Venturi steam meter. The suction water tank enables the quantity of water withdrawn to be measured, and the delivery passes through a Siemens & Halske feed water meter fitted with a rocking disc into pressure tanks fitted with a water gauge. The pressure in these tanks can be maintained at any desired figure by means of an air compressor, and the water can be drawn off into measuring vessels through a throttle valve. It will be seen that the quantity of water can be measured in three ways in the case of feed pumps and in two ways with injectors. The same equipment is used for calibrating the water meters used on locomotives being tested. To enable tests to be made under all possible conditions the suction head and water temperature can be varied within the limits that occur on locomotives.

During the tests, indicator diagrams are taken on the steam and water cylinders of the feed water pumps, on the

suction and delivery air vessels and on the suction and delivery pipes, also diagrams of the motions of the pistons and valves. The causes of any noises are investigated by ear.

The equipment is capable of testing the adequacy of feed water arrangements in respect of reliability, output, regulation and economy or possibility of the lack of these.

The lubrication of pistons and slide valves is of outstanding importance from the point of view of its effect on the wear of the walls and rings, and special attention is therefore given to the testing

Fig. 6. — Testing equipment for oil pumps.

of lubricating pumps and oil valves. The testing equipment for oil pumps, figure 6, is arranged so that the pumps under test can be coupled to a crank whose stroke can be varied. The base of the pump can be heated and the oil thus maintained at a steady temperature. Each lubricating point to be served by the pump is connected to a pressure vessel by a separate pipe and the pressure vessel is fitted with a manometer to show the pressure against which the pump is working, and an adjustable valve through which the oil passes to measuring vessels. It is thus possible to ascertain the volume of oil that can be delivered against any pressure from 0 to 250 atm. (3 555 lb. per sq. inch) with varying adjustments of the pump and stroke, and to ascertain the volumetric efficiency. The oil pumps that are now used for the lubrication of air pumps and water pumps are tested on similar lines, but in this case an old air pump is used for driving them in order to imitate normal working conditions as nearly as possible.

An engine driver noticed one day that after closing the regulator of his locomotive (on her maiden run) the oil pipes ran empty, and that on starting again, steam entered the oil pipes and also partly the pumps. Experiments showed that the non-return valves, the so-called oil check valves, did not work as they should do. When they remained tight, they were closed by the steam pressure, and only after an interval was the flow to the lubrication points resumed, when the pressure in the oil pipe had risen several atmospheres above the pressure in the valve chest; on coasting the oil ran out of the pipes. This occurrence was due to the excessive amount of air present in the oil. New types were designed in order to remedy these drawbacks. For carrying out suitable tests, a pressure vessel was devised, figure 7, with a window of thick glass through which the oil drops could be observed. This vessel was filled with steam and emptied quickly; later on it was found that compressed air was more convenient for observation. The check valves fitted to the vessel are kept at the same temperature as a locomotive cylinder by an oil bath. The oil pressure and air pressure are shown by gauges and their readings serve to show when air enters the oil pipe, *i. e.* the check valve is not tight; further it is possible to ascertain whether the valve permits the drops of oil to pass at regular intervals irrespective of changes of pressure, and prevents the emptying of the oil pipe when the pressure ceases altogether.

An arrangement has been worked out

and put into practical form for investigating the wear on the rings of pistons and slide valves, particularly in regard to the variations of wear at different points on the circumference. This device, shown in figure 8, enables the pressure of the rings on the internal surfaces of sleeves and cylinders to be measured at any point along the surface. Adjustable rollers arranged on an iron frame at equal intervals, can be set, by means of a former, to the diameter of the cylinder in which the test ring is

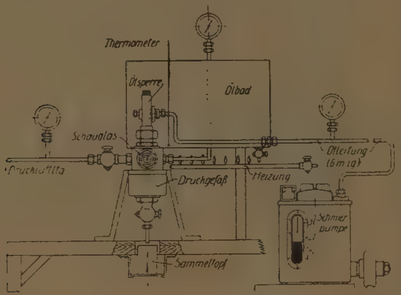

Fig. 7. — Diagram of equipment for testing oil check valves.

Explanation of German terms:

Druckgefäss = Pressure vessel. — Druckluftltg = Compressed air pipe. — Heizung = Heating arrangement. — Ölbad = Oil bath. — Ölleitung (6 *m* lg.) = Oil pipe (19 ft. 8 in. long). — Ölsperre = Oil check valve. — Sammeltopf = Collecting vessel. — Schauglas = Inspection window. — Schmierpumpe = Lubricating pump.

used. In place of the lowest roller there is a mercury pressure measuring device which can also be adjusted vertically. To measure the radial pressure exerted by a ring it is placed concentrically side by side with the former, so that the rollers bear on both, and the ring only is in contact with the measuring device. The latter is then screwed up until the ring at this point is exactly level with the circumference of the former as shown by an indicator, and the radial pressure exerted by the ring on the cylinder is transmitted to a column of mercury in a glass tube, from which a reading is taken. By turning the ring round, the pressure of every point on its circumference can be measured and the results can be plotted on

Fig. 8. — Apparatus for measuring radial pressure of piston rings.

a curve as shown in figure 9; the accuracy with which the ring has been finished can then be judged. The pressure

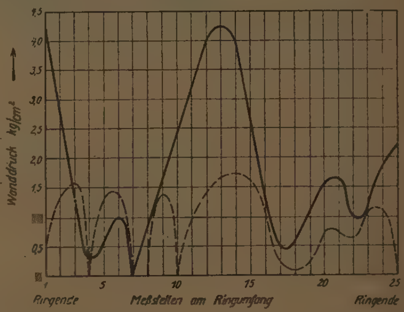

Fig. 9. — Radial pressure of a piston ring: ——— before fitting - - - - - - when removed after 90 000 loco-km. (55 925 locomotive-miles).

Explanation of German terms:

Messstellen am Ringumfang = Points at which measurements made round ring circumference. — Ringende = End of ring. — Wanddruck *kg/cm²* = Radial pressure kgr. per sq. cm.

measuring device can easily be calibrated by weights.

Experiments are always in progress on a large number of engines for the purpose of ascertaining the resistance to wear of valve rings and piston rings, ebonite rings for water pumps, bushes, etc. The result of tests under operating conditions are subject to many incidental circumstances, and therefore, in order to test the wear of materials of various kinds running in contact with one another, independent of variations in the lubrication, a testing machine was constructed of the type shown in figure 10. Two slides to which the test pieces can

Fig. 10. — Machine for testing wear.

be attached are connected to two cranks, set 180 degrees apart, so that they can be given a reciprocating motion at any desired speed. The test pieces are pressed, by means of adjustable springs, into contact with fixed strips of the material with which they have to run in practice. A constant temperature is maintained by compressed air cooling. At definite intervals observations are made of the loss of weight of the test pieces.

A test bed for locomotives and rail motors now renders it possible to conduct tests on vehicles in the hall of the locomotive test department, away from the running track. A description of this equipment will be given at the conclusion of this article by Reichsbahnbaumeister Solveen, who has been responsible for its construction.

If needed, a locomotive is made use of as part of the testing equipment and taken away after the experiments have been completed. For example, exhaust steam injectors are mounted for testing on an engine from which live steam is

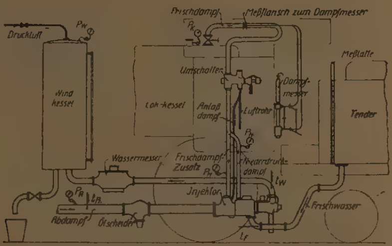

Fig. 11. — Equipment for stationary tests on Friedmann exhaust steam injector.

Explanation of German terms:

Abdampf = Exhaust steam. — Anlassdampf = Steam for starting. — Dampfmesser = Steam meter. — Druckluft = Compressed air. — Frischdampf = Live steam. — Frischdampf Zusatz = Auxiliary supply of live steam. — Frischwasser = Freshwater. — Injektor = Injector. — Lok-Kessel = Locomotive boiler. — Luftrohr = Air-pipe. — Messlatte = Dip stick. — Messflansch zum Dampfmesser = Flange for connection to steam meter. — Niederdruckdampf = Low-pressure steam. — Ölscheider = Oil separator. — Umschalter = Change over cock. — Wassermessor = Water meter. — Windkessel = Air vessel.

taken through a throttle valve, see figure 11. The water, taken from a tender arranged so that the quantity can be measured, is delivered from the injector through a hot-water meter into a tank in which the pressure can be regulated by means of compressed air; the quantity flowing out of the tank is again measured. The quantity of live steam used is controlled by diaphragms. The exhaust steam recovered can be calculated by subtracting from the total quantity of water, the quantity drawn from the tender, the weight of live steam, and the leakage water. The volume can be checked by temperature measurements,

and also the efficiency of the injector calculated.

Water gauges are tested for the reliability of the automatic ball checks, the glasses for durability, and protective arrangements for their behaviour in case of breakage of the glass; these tests as well as the tightness of boiler feed valves and mud valves are carried out with the apparatus mounted on a stationary engine.

Locomotive whistles and other acoustic warning devices are tested in a similar manner and when necessary arrangements are made to measure the quantity of air used; by testing them on an engine it is possible to ascertain the precise effect of the sound produced.

It was found that one dynamometer car was not adequate for the measurements required when investigating the many classes of locomotives built since the war, of the series 39 (P 10), 95 (T 20), 01, 02, 05, 24, 43, 44, 62, 64, 70, 80, 81, 86 and 87, and the experimental engines with turbines or Diesel engines, or with high-pressure boilers and powdered fuel. A coach that was formerly part of a royal train was accordingly converted, in 1923, into a measuring vehicle. A description of this locomotive test coach (No. 2) has already been published in the *Organ für die Fortschritte des Eisenbahnwesens* (1926, vol. 20, p. 397), by Professor Dr.-Ing. Nordmann. The measuring coach

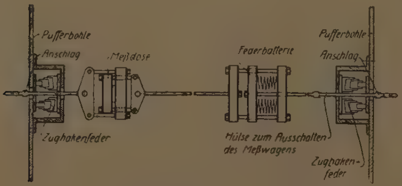

Fig. 12. — Draft-gear for dynamometer coach.

Explanation of German terms:

Anschlag = Stop. — Federbatterie = Compound spring. — Hülse zum Ausschalten des Messwagens = Sleeve for cutting out instrument coach. — Messdose = Measuring device. — Pufferbohle = Buffer beam. — Zughakenfeder = Spring of draw hook.

No. 1, described by President Dr. Hammer, in *Glasers Annalen* (1911, vol. 68, p. 201, and 1916, vol. 78, p. 4), has also been partly re-equipped with new apparatus in accordance with the advances that have been made in methods of measurement. In order to obtain more

Fig. 13. — Tractive effort measuring device for small values of tractive effort.

space the Amsler dynamometer was dispensed with, its results having proved unreliable, also the instruments for superstructure investigations, for which a special carriage had been fitted up and the unused apparatus for measuring propulsive effort.

A system of springs was incorporated in the draft gear in order to minimise the transference to the recording strips of the variations in pull due to the lack of uniformity in the tangential pressure diagram and to the reciprocating masses of the locomotive. These springs are shown in figure 12. The draft gear was also so arranged that, whatever the direction of travel, the pull from the engine hook acts directly, on the measuring device before it comes on the dynamometer car; this obviates the necessity of having to turn the latter round. When it is desired to measure the resistance of a hauled vehicle, *e. g.* a locomotive with Riggenbach brake, a sleeve can be fitted on the draw bar of the dynamometer coach so that the pull on it does not act on the measuring device and consequently its resistance is eliminated from the

measurements. The measuring device now measures up to 20 tons instead of the former 18 tons; as its readings are inaccurate in the lower part of the range, from, say, 1 500 kgr. (3 300 lb.) downwards a new device, figure 13, has

Fig. 14. — Arrangement of instruments on measuring bench.

been constructed for tractive efforts up to 3 000 kgr. (6 600 lb.). This can be substituted for the coupling between the instrument coach and the vehicle being tested, and it operates an indicating and recording manometer in the instrument coach. The instrument table now carries only two measuring strips driven from the axle; they are 120 mm. (4 3/4 inches) wide and are acted upon by two tractive effort recorders, figure 14. Following a proposal of the experimental department the new recording steel-tube manometer was fitted with two Bourdon tubes which give the actuating force of a double tubular spring; this arrangement definitely overcomes the frictional resistance of the new planimeter purchased from Messrs. *Ott*, of Kempten, for integrating the tractive effort charts. Calibration of the large tractive effort meter is effected, as hitherto, by Dr. *Wazau*'s instrument and this is checked periodically by the *Materialprüfungsamt* (State Bureau for Testing Materials); the tractive force is produced hydraulically. The small tractive effort meter is calibrated by being hung on a crane and loaded with weights up to 3 000 kgr. (6 600 lb.). When these calibrations are carried out every quarter, the opportunity is also taken to check the accuracy of the planimeters. Since the meters and also the planimeters have an error of plus and minus 1 % within the range utilised, and the possible error may thus be plus and minus 2 %, the combined calibration is plotted as a correction curve for subsequent use when analysing the results of the tests. Comparative tests between the two meters at small tractive efforts have so far shown a difference of less than 1 %.

The old speed recorder was replaced by two new eddy-current tachometers supplied by the *Deuta* Works, Berlin, work-

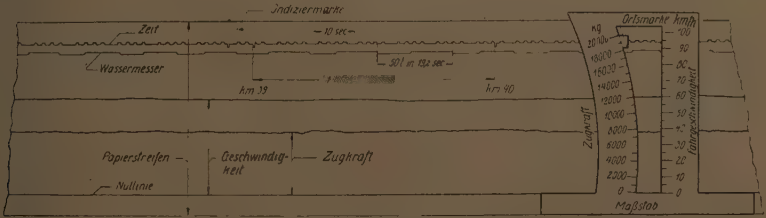

Fig. 15. — Strip for recording tractive effort.

Explanation of German terms:

Fahrgeschwindigkeit = Running speed. — **Masstab** = Scale. — **Geschwindigkeit** = Speed. — **Indiziermarke** = Reference mark. — **Nullinie** = Zero line — **Ortsmarke** = Location marks. — **Papierstreifen** = Paper strip. — **Zeit** = Time. — **Zugkraft** = Tractive effort.

ing independently of one another. One of these indicates the r. p. m. and the other records the speed of travel on both the recording strips. Tractive effort and speed are recorded on the strip (fig. 15) with the same zero line but with different abscissæ. A two-second time scale is recorded by a clockwork, every fifth indentation being omitted to facilitate the reading of time intervals. The same stylus that records the seconds line also marks kilometres by similar indentations. Each 50 litres (11 Imp. gallons) of feed water used can also be recorded in accordance with the measurements furnished by the water meters, of which one or two are mounted on the locomotive being tested. This enables the delivery per minute to be calculated, as is

Fig. 16. — Observer's side of instrument bench.

essential when performance tests are being made on preheaters and feed water pumps. The recording lines are drawn by sharp pointed glass tubes filled with inks of various colours. The instrument benches are now arranged longitudinally and not crosswise (figs. 16 and 17). The observers carrying out the tests stand behind the benches, and visitors in front, so as to interfere as little as possible with the work. Visitors are able, nevertheless, to see the indications of the instruments since the tachometers, tractive effort and braking manometers, etc. are provided with scales and pointers at the back as well as at the front. The actual time of running with regulator open is recorded by a clock that is started and stopped from a contact on the regulator, and a pair of wheels similarly controlled measures the distance run in metres. A special warning device operated either from the axle or from a clockwork permits a contact to be closed at any predetermined points on the

Fig. 17. — Observer's side of instrument bench.

journey at which observations have to be made in the dynamometer car and on the locomotive; a mark is made on the chart independently of observers at these points, which may be from 0.5 to 5 km. (0.31 to 3.1 miles) apart according to the speed.

Special importance is attached to ascertaining the thermic efficiency of locomotives being tested.

All important temperatures are recorded continuously by the three-colour ink recorders driven either from an axle or from a clock (distance run or time). At

less important points use is made of the well-known type of indicating instrument already described by President Dr.-Ing. Hammer. Practically all temperature measurements are made by platinum-resistance thermometers of 50 Ω at 0° C. (32° F.). The form of these instruments has undergone considerable change from time to time and their development is illustrated by figure 18. The platinum coil is sealed in quartz-glass on which silver wire is wound and the whole is protected from damage by a casing. In designs A and B, figure 18, the casing was an iron tube which conducted a great loss of heat and caused a considerable lag (up to ten minutes) in the recording, giving rise to errors of as much as 40° C. (104° F.). In design C the platinum was surrounded by a copper tube and this reduced the lag to about two minutes. The absorption of heat was not eliminated, however, in spite of the iron case which provided an outlet for the hot gas or vapour and served to convey heat to the copper tube; the temperature error still reached 10°. In the latest method of mounting resistance thermometers, figure 18 D, E and F, the resistances have a plain copper enclosure for measuring water temperatures, while for measuring steam and gas temperatures the copper casing has fins that are longitudinal or transverse according to the direction of flow. The copper casing is welded to a tube of poor heat-conducting material such as steel or a nickel-steel alloy. With this construction the heat absorption is negligible and the lag has been reduced to less than one minute.

There have been similar changes in the head of the thermometer. The terminals were for a short time reduced to the form of figure 18C, but they are now completely enclosed in the top cap to protect them from mechanical injury; a cover makes them watertight. Obviously, the indications of the resistance thermometer are often compared in an oil bath with the mercury thermometers, which are frequently checked by the State Physico-Technical Laboratory in order to detect errors and eliminate variations of more than 3° C. (5.4° F.).

The leads of the temperature indicators in the dynamometer car are carried from both ends of the car to its centre and from there to the measuring devices. This permits the coach to be run in either direction, *i. e.* without being turned round, without the accuracy of the temperature indications being affected by unequal lengths of lead, that is to say, by unequal ohmic resistance.

Fig. 18. — Platinum resistance thermometers.

In order to control the firing, a sample of flue gas is drawn off from the smokebox continuously by a gear pump into the instrument coach and passed through a Siemens & Halske testing apparatus. The CO_2 and $CO + H_2$ content can thus be read on an indicator at any time, and if necessary, can also be recorded on a chart. To provide for an exact average analysis to be made subsequently, samples taken from a uniform gas stream are passed into a rubber bag at regular intervals throughout the test run; the contents are then tested with an Orsat apparatus.

When tests are made during the winter on trains running in public service, the steam used for heating cannot be

considered as part of the steam consumption for test purposes, and it is accordingly measured separately on its way through the instrument coach.

Locomotive indicators have changed slightly in outward form, but otherwise have been very little improved in the last fifteen years. The springs are calibrated every six months by a special apparatus. The method of driving the cylinder has certainly been improved by the use of wire cord that is little liable to stretch, and by better reduction devices, but unfortunately it is still liable to errors. The lack of accuracy in these indicators is still considerable especially when the locomotive is running at high speeds.

Special indicators have been obtained from Messrs. Maihak for Diesel locomotives; these enable diagrams to be taken up to 400 r. p. m. and are fitted with the electric remote control that has already proved satisfactory on steam engine indicators.

New methods for carrying out scientific investigations on locomotives by means of test runs with an instrument coach.

The preparations in connection with test runs have to be made with the utmost completeness if inaccurate measurements and the repetition of the costly tests are to be avoided.

In the first place, the test programme has to be planned. The measurements to be made are decided upon as well as the instruments that are to be fitted onto the locomotive. The observations that are to be made should be grouped in such a way that they can all be taken in the available time by allotting them suitably to the observers. Appropriate record books are then prepared, also appropriate forms and calculation blanks for working out the results. Decisions have to be made as far as possible concerning the scope of the tests, the number of runs, and the various speeds and loads at which the locomotive shall be tested.

As part of the preparation for tests on steam locomotives — the only type considered herafter — the steam paths are examined. The pistons and valves are inspected, the steam and exhaust lap and passages checked, and rings that are fractured or have too large a clearance are replaced. Any rings that are gummed up with oil are loosened. Cylinders, valve chests and exhaust passages are cleared; the clearance spaces of the cylinders are measured by filling them with water.

The lubrication of the pistons and valves is checked. The superheater, inlet and exhaust passages of the valve chests, and the valve liners are filled with water under pressure in order to detect leakage; such leakage is found chiefly in superheater elements and valve liners. Pressure equalisers and air inlet valves are tested for tightness. The distance of the return bends of the superheater elements from the firebox tube plate is measured. The correct position of the blast pipe in relation to the chimney is checked by a special device. Measurements are made, also, of the blast pipe diameter, the dimensions of the chimney and the distance between the upper edge of the blast pipe and the chimney. The boiler is washed out, and when firing up, examination is made of all pipes, stay bolts, rivets, manholes, domes, etc., to see that they are tight.

For measuring the temperatures of the combustion gases three resistance thermometers are fitted into the smokebox, each being 500 to 1 000 mm. (1 ft. 7 11/16 in. to 3 ft. 3 3/8 in.) long. One is fixed immediately in front of the small flues and one in front of the large flues in order to ascertain whether the flue gases give up approximately the same quantity of heat to the various tubes, and therefore whether the tube measurements are satisfactory. A thermometer in the centre of the smokebox gives the mean tem-

perature of the flue gases before they leave the box.

The steam temperature is measured first of all just before it enters the superheater chamber, and them immediately behind the valve chest if possible on all the cylinders, in order to get accurate values for this important figure and obviate the nullifying of a test in the event of an accident to one thermometer. The difference between the two temperatures is only a few degrees if they are measured at the correct points.

The temperature of the steam issuing from the cylinder is measured on the exhaust side of each, and if necessary on both sides of each cylinder, this gives a ready means of detecting any want of tightness in the piston or valve rings, or in the pressure equalisers. The feed water temperature is measured by resistance thermometer on both sides of the exhaust steam preheater or injector. The temperature of the feed water in the tender remains practically constant during a test run and is measured by a mercury thermometer. Special care is taken when fitting all resistance thermometers that they are inserted a minimum depth of 200 mm. (7 7/8 inches) in order to obviate errors consequent on heat being conducted away. For the same reason the thermometers are always placed in the centre of the flow and when possible at pipe bends.

The vacuum in the smokebox, firebox and ashpit are measured by glass « U » tubes provided with a damping arrangement; these are mounted in the cab and connected by rubber tubing to copper piping run to the three positions in question. Each valve has a millimetre scale so that the amount of vacuum can be read off in millimetres of water. Similar arrangements are made for measuring the vacuum at the narrowest point and the orifice of the chimney and these measurements throw light on the correct shape and dimensions of the latter.

The manometers for the boiler, valve chest and receiver are calibrated against a standard manometer. A low-pressure manometer is connected to the exhaust pipes at a point below the blast pipe, a condensation trap and a constant head of water being interposed in the connecting pipe.

The combustion gases are drawn out of the smokebox by a ring pipe and are led away through a copper pipe having a uniform fall, to a filter wherein condensed water and flue dust are caught as far as possible, the former in *Raschig* rings, the other in a « Delbag » filter followed by glass wool and wadding. Rubber hose is used instead of rigid iron piping between the locomotive and tender, and between tender and instrument coach.

Indicators are fitted on the locomotive cylinders. The connections on the indicator are connected to the indicator cock. Pipes of large diameter, but as short as possible, and well insulated on the outside, connect the indicator piping to the cock enabling the connection to be emptied and diagrams to be taken first on one side of the cylinder and then on the other. The indicator cocks are operated from the cab by a special rod and spindle. A wood lever has been found satisfactory for transmitting the motion of the crosshead to the indicator drum, and in order to reduce to a minimum the errors due to this transmission the best position for the lever has been made the subject of experiment. It is fitted accurately with the aid of a jig. The Maihak indicator is operated electrically from the driving cab by current supplied from the instrument coach.

The locomotive feed water is measured accurately by means of a Siemens & Halske hot water meter provided with rocking dial and fitted in the feed water pipe between the preheater and the cock from which water is drawn for damping the coal; its indications are transmitted electrically to the instrument coach. When necessary the boiler capacity is determined accurately and the water

level indicator calibrated so that the quantity of water in the boiler at any time can be read off.

The live steam make-up for exhaust injectors, and the steam used for the auxiliaries of locomotives using pulverised fuel, or of turbine locomotives, etc., can be measured by means of steam meters and diaphragms inserted in the steam piping.

The air pump is fitted with stroke counters driven from a rod that passes through the upper cylinder cover. The steam taken per stroke is known, and hence the total steam consumption is easily determined.

A special contact is fitted so that it is closed when the regulator is opened and this operates the instrument which records the steam consumption of the locomotive as a function of the time and of the distance run.

The whole of the electric leads from the thermometers, water meters, regulator contact, etc., are brought into a terminal box, which also contains the telephone and the signalling horn. It is connected to the instrument coach by one or two 37-strand cables. Plugs on these cables enable the circuits between the coach and the locomotive to be readily coupled up, and in the event of the train parting, the plugs are pulled out before the cable stretches taut, and damage is thereby avoided.

The water tank on the tender is calibrated and a measuring stick provided so that a check on the feed water is available in addition to the water meter already mentioned.

The locomotive and tender are weighed empty, filled, and three-quarters filled with coal and water. The coal space on the tender is divided into several compartments by wood partitions which are filled with accurately weighed quantities of coal.

In order to be able to make comparative tests between locomotives on a thoroughly reliable basis it is necessary to obtain absolute measurement values, and for this purpose the locomotives must be tested under steady conditions. Perfectly steady performance is not possible on the track because even the best section of line is not absolutely horizontal and straight, and the strength and direction of the wind change. Nevertheless it is possible to run with a constant indicated output. If the reversing gear is kept in the same position, and the pressure in the valve chest is kept constant conveniently at 1 atm. (14.22 lb. per sq. inch) below the boiler pressure, by adjusting the regulator, all that is necessary is to run at a constant speed. The desired conditions can be realised by making use of braking locomotives which dissipate the energy of the test locomotive by compressing air. The complete test train therefore consists of the locomotive under test, the instrument coach, and one or more brake locomotives, as shown in figure 19.

The brake locomotive is an ordinary engine equipped with an additional Riggenbach brake. When the valve gear is put into the reverse direction the locomotive acts as an air compressor, air being sucked in on the exhaust side and expelled on the steam side. The entrance of ashes is prevented by closing the blast pipe by a rotatable cover, and connecting it directly to the outside atmosphere. Hot water from the boiler is sprayed into the exhaust box, and being absorbed by the air that is drawn in, the moisture acts as a cooling medium on the next compression stroke. Valves are provided for regulating the pressure in the steam pipe, or in the superheater, into which the compressed air is forced, and these valves can be adjusted by the driver as required. The compressed air escapes into the open air through a silencer.

Alteration of the load exerted, and therefore of the speed, is effected by regulating the degree of compression, mainly by changing the valve gear. For greater facility in checking the speed

Fig. 19. — Experimental train made up of test locomotive, dynamometer coach, and several braking locomotives.

large « Deuta » tachometers are fitted. The maximum pull that a brake locomotive can exert continuously has been found one-tenth of its adhesive weight. If an attempt is made to obtain more than this, difficulties arise; the locomotive skids, readily insufficient heat is carried away from the cylinders, the temperature of the compressed air becomes too high and consequently the lubrication is no longer adequate. Moreover the connecting rod bushes and cross head slides will not stand up continuously agains a greater load.

In addition to the merit of the brake locomotive for regulating the speed and load easily it has a number of other useful features. It can be used for assisting to bring the train up to speed and the desired conditions of steady running can be obtained much more quickly, thereby using the available length of track to the best advantage. When heavy loads are required, an ordinary train would be so long that it could not be made up in a station, and on busy lines the necessary number of vehicles could not always be spared. Shunting operations performed by the self propelled train as represented by the brake locomotive is carried out quicker and more easily.

The water carried in the tender of the test locomotive may not be sufficient for a long run, and the brake locomotive provides the possibility of transferring some of its water to the test engine through a pipe run underneath the instrument coach; the duration of the test can thus be planned without regard to the water capacity of the test engine. The water measurements are not affected if the water taken from the brake locomotive is passed through a meter.

When testing new locomotives, especially purely experimental designs such as engines of the high-pressure, Diesel, or turbine type, it is not always possible to avoid difficulties arising on the running track, and in such cases the brake locomotive can be reversed in a few seconds and instead of braking can be used to clear the track quickly for oncoming trains. It is very convenient also to be able in Winter to heat the instrument coach and provide it with hot water from the brake locomotive.

Nevertheless the employment of a brake locomotive does not render the tests independent of the track. The best conditions are present when the brake engine is utilised on a straight, horizontal track, since there is then no resistance

due to curves and the influence of the wind — which should not be underestimated — remains constant. Although the effects of rising or falling gradients can be taken into consideration, they render it very difficult for the driver of the brake engine to keep the speed constant. Moreover, on steep down gradients it is impossible to check the test locomotive when it is being worked at a high duty, since the combined gravitational forces of the whole train has to be absorbed. The hand brake on the instrument coach has moreover to be brought into use to prevent the coach running on to the locomotive and increasing the pull transmitted to the tractive effort measuring device. Another point in connection with the choice of the section of track used for tests, is its length; this should be as great as possible in order to permit long runs and therefore greater accuracy in measuring fuel consumption.

The accuracy of the measurements suffers also if the test is commenced before the engine has properly warmed up, and a run of at least 20 to 30 km. (12.4 to 18.6 miles) should be made before any readings are taken. All the essential requirements are fulfilled by the Grunewald-Potsdam-Burg-Magdeburg line on which the section Potsdam-Burg, 92 km. (57.2 miles) long, is used for taking the measurements. A speed of 40 km. (25 miles) per hour can be maintained for 2 1/4 hours, and of 100 km. (62 miles) per hour for 55 minutes. Not only is this line near to the experimental stations at Grunewald, but it has also other advantages such as turntables situated conveniently at Brandenburg, Kirschmoser, Genthin, Burg and Magdeburg, which enable tests to be made on shorter sections when necessary.

Under normal operating conditions the driver controls his engine on gradients as may be necessary to maintain the timetable. When tests are being carried out it is important that only one condition should be altered at a time if a proper investigation is to be made of the effect of varying the speed, cut-off, steam pressure, boiler output, etc. The tests are therefore a purely scientific character and are carried out at a constant speed. The only variable quantity during a series of tests is the cut-off point, and if the test engine does not allow of this being varied sufficiently, the pressure in the valve chest is varied by the regulator.

Measurements made when the locomotive is working at small outputs are inaccurate to the extent that windage and instrument errors have a greater effect. Two runs without load (tractive effort = 0) are therefore made with every locomotive on the same day in both directions along the selected stretch of line. This is done in order to eliminate, as much as possible, the effect of the wind. These light runs give a reference mark on the test curves that are subsequently plotted, and thus enable their course to be determined more accurately; for example, the curve of water consumption shown in figure 20 would have been drawn in the position of the dotted line if the light running mark had not been ascertained. As the light runs are made at various speeds the results obtained can be checked reciprocally.

For the purpose of the tests the maximum output of an engine is taken to be that at which the steam consumption corresponds to an hourly boiler performance of 57 kgr. per m² (11.67 lb. per sq. foot) per hour of heating surface. This figure represents the rate of steaming that can be maintained for periods of an hour or more, at any rate in large boilers, the tightness of the tubes being taken into consideration. With normal grate firing this figure can be exceeded without hesitation on smaller boilers of less than 150 m² (1 615 sq. feet), especially when they have narrow fireboxes. A rate of steaming higher than 57 kgr. per m² per hour is permissible also for

short periods on large boilers, largely by reason of the considerable reserve given by their large water capacity.

As a rule the groups of tests at constant speed are followed by a series of runs at a steam output of 57 kgr. per m² (11.67 lb. per sq. foot) of the heating surface, per hour, *i. e.* the boiler with

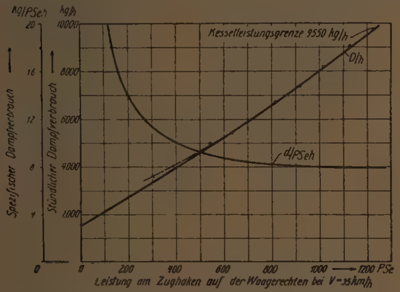

Fig. 20. — Hourly and specific steam consumptions of locomotive G 8², number 56 2131, at a speed of V = 35 km. (21.7 miles) per hour.

Explanation of German terms :

Kesselsleistungsgrenze 9 550 *kg/h* = Maximum boiler output 9 550 kgr. (21 050 lb.) per hour. — Leistung am Zughaken auf der Waagerechten bei V = 35 *km./h* = Output at draw hook on the level at speed of V = 35 km. (21.7 miles) per hour. — Spezifischer Dampfverbrauch = Specific steam consumption. — Stündlicher Dampfverbrauch = Hourly steam consumption. — PSe *h* = Effective H. P. per hour.

constant boiler output for different speeds, the speed however remaining constant during one and the same run.

We call these runs « boiler limit runs » and this expression must be interpreted taking into account the considerations set out above. The performance characteristic of the locomotive is thus obtained.

In order to ensure that the desired steam production is attained during the test runs, the degrees of cut off, which have already given accidentally the required thermal output of the heating surface during the runs at constant speed, are plotted against the speed as abscissæ, and a curve is drawn. This curve gives the required setting of the valve gear corresponding to a boiler-limit run at any particular speed. The vacuum in the smokebox serves as a check on the maintenance of the correct rate of steaming, since it remains constant as long as the boiler output is contant.

The maximum tractive effort at starting is determined by coupling the test locomotive, on a sanded track, to a fully-braked instrument coach that is anchored to one or two fully-braked locomotives. With the most varied positions of the cranks and the valve gear right over, steam is admitted to the valve chest at full boiler pressure in the case of compound engines at the maximum pressure permissible in the receiver. The tractive effort measured in the instrument coach is plotted against the distance to be moved through at starting and represents the diagram of tangential pressures referred to the wheel periphery, minus the running resistance of the locomotive.

If special apparatus has to be tested on a locomotive, appropriate testing arrangements are devised. For example, a counter-pressure brake is tested by coupling the test locomotive behind an instrument coach, the latter having a special device on the draw-bar which permits the tractive effort to be measured exclusive of the resistance of the coach (fig. 12). The coach and counter-pressure engine are hauled along a length of track of known gradient at a constant speed by one or several powerful engines; during the run the pressure in the valve chest of the engine under test is varied by means of the regulator valve, the position of the valve gear remaining unaltered.

Measurements are taken of the tractive effort and the temperature of the compressed air and diagrams are taken on the cylinders. Steady conditions are attained in a comparatively short time, so that the valve chest pressure can be altered every 10 or 20 km. (6.2 to 12.4

miles). The complete range of counter-pressure braking can thus be taken on one run.

Similarly, tests are carried out on equalising valves, and equalising piston valves. The test engine runs for 10 km. under steam and then 10 km. with steam shut off. Temperatures are taken to ascertain the heating of the air that is pumped through the equalising valve from one side of the cylinder to the other, and on the subsequent run under steam, observation is made of the continued thightness of the equalising valve. Indicator diagrams give the work done in the cylinders by compression during the period of running with steam shut off. These tests are carried out at different speeds, especially at high speeds.

During a test run, the boiler and valve chest pressures, the position of the valve gear, the partial vacuum in the smokebox, firebox, ashpit, and upper and lower part of chimney, the reference number of each diagram, and the point on the route at which the readings are taken are recorded, and the apparatus for taking the indicator diagrams is operated. Samples of coal are taken during the progress of firing and these are subsequently analysed and the calorific value determined in the Railway Laboratory. Notes are made by the observers in the instrument coach of the location, tractive effort, speed, combustion gas temperatures in the smokebox, degree of superheat, and the temperature of the exhaust steam and of the feed water on both sides of the preheater; additional temperature readings are taken when necessary for a particular investigation. The recording charts in the instrument coach show the tractive effort and speed, the location, and the water consumption; also the point at which each indicator diagram is taken. An eventual comparison taken at identical moments of the values of the indicated and effective tractive effort can thus be made. The signalling apparatus referred to above and connecting the locomotive and the instrument coach, ensures that readings are taken at the same moment in both places.

The water level in the boiler is adjusted to exactly the same height at the beginning and end of a test, with the engine standing on a level piece of track, the boiler pressure being identical. The feed water consumption is given by the difference between the readings of the water meter; also by the difference in the contents of the tender as measured with the dip-stick. Coal for the run is used from the compartments previously arranged in the tender, and any that remains is weighed after the conclusion of the test. In the event of the quantity being insufficient, briquettes of known weight are used and their number is counted. The quantity of fuel in the firebox is estimated before and after the run.

From the records of the steam consumption as a function of the distance and time run, the effective running speed can be calculated. The work done is given by the automatic integration of the tractive effort chart during the run, and the average output during the test is derived by dividing the total figure by the duration of the run in minutes, and multiplying by the particular constant of the apparatus.

It is important to calculate the principal results immediately after each test run; this applies to the horse-power output, the steam and water consumption per hour and per effective H. P., as well as the steaming performance of heating surface. By doing this it is possible to recognise at once whether the test has been satisfactory or whether it is necessary to repeat it; or it may reveal the necessity of interrupting the tests for the carrying out of some improvement in the locomotive. The various details of the locomotive, such as feed pumps, injectors, oil pumps, pressure equalisers, pyrometers and tachometers, are observ-

ed and tested as far as possible during the experimental runs. If any of them appears to be faulty, the cause is investigated and the defect remedied.

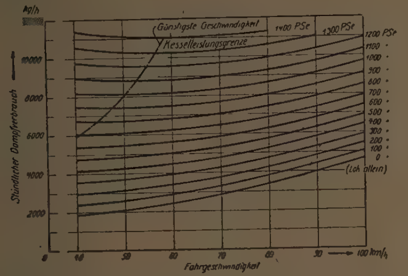

Fig. 21. — Hourly steam consumption of standard locomotive, No. 62 001, for various boiler loads and speeds of 40 to 100 km. (24.8 to 62.1 miles) per hour.

Explanation of German terms:

Fahrgeschwindigkeit = Travelling speed. — Günstigste Geschwindigkeit = Most favourable Speed. — Kesselleistungsgrenze = Maximum boiler output. — Lok. allein = Loco. only. — PSe = Effective H. P. — Stündlicher dampfverbrauch = Hourly steam consumption.

The results that are worked out immediately after the termination of the run are only of a preliminary nature, and the whole of the figures are thoroughly checked at the office. The indicator diagrams are planimetred with the utmost care and the mean values of the readings on the locomotive and instrument coach are obtained by using a calculating machine. The correctness of the measured water consumptions can be checked very well by plotting the readings against the effective output (fig. 20), and also against the indicated output; the latter is especially valuable in permitting a correct estimation of the effect of wind. In addition to the hourly steam consumption, the specific steam consumption, valve chest pressure, blast pipe pressure and cut off are plotted separately for each speed against the effective output. The measured water consumptions per hour can be checked by plotting them against the speed in kilometres on a separate curve for each output (*e. g.* 500, 800, 1 000 effective horse-power).

The indicator diagrams are unfortunately not free from errors, due to the inertia of the parts, the imperfection of the reduction linkwork and the stretching of the cord, and the error increases with the speed. As the speed increases the mean indicated pressure becomes increasingly lower than the correct value. As a result of these errors all measurements of indicated horse-power are only comparative and not absolute values.

Since, moreover, the indicated values are somewhat dispersed owing to small variations in the steam pressure, the friction of the indicator piston, etc., the values of indicated tractive effort are plotted with the effective output or tractive effort as abscissæ (fig. 22). If the effective tractive effort is plotted on the same sheet and to the same scale a straight line results, which passes through the origin. If the values are correct, the curve of indicated tractive effort must deviate more and more from the effective tractive effort as the output in-

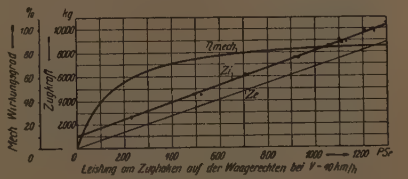

Fig. 22. — Mechanical efficiency of G 12 locomotive No. 58 1596 at a speed V = 40 km. (24.8 miles) per hour.

Explanation of German terms:

Mech. Wirkungsgrad = Mechanical efficiency. — Zugkraft = Tractive effort.

creases. The effective tractive effort divided by the indicated tractive effort gives the mechanical efficiency.

All measurements connected with the boiler can only be referred to the rate

of steaming. Neglecting the small cooling losses, the speed at which the locomotive hauls the boiler is of no importance. Consequently all measurements of coal consumption, and steam and flue gas temperatures are plotted against the rate of steaming, in kgr. per m² per hour or against total water consumption, in kgr. per hour, irrespective of the speed. The manner in which the curve of hourly coal consumption of a locomotive is plotted in this way is shown in figure 23. The consumption figures are previously converted to a common basis of heat content according to the calorific value of the particular fuels used. Curves are

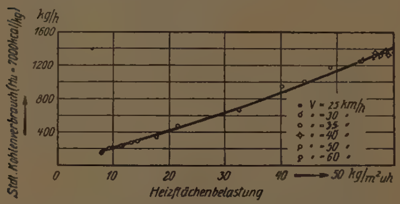

Fig. 23. — Hourly coal consumption of G 8² locomotive No. 56 2131 at various speeds and at steaming performances of 0 to 60 kgr. per m² per hour (12.28 lb. per sq. foot).

Explanation of German terms:

Heizflächenbelastung = Steaming performance. — Stdl. Kohlenverbrauch (Hu = 7 000 *kcal/kg*) = Coal consumption in kgr. per hour (calorific value = 13 675 B. T. U. per lb.).

then plotted with the specific coal consumption in kgr. per effective H. P.-hour, the live steam temperatures, and the exhaust temperatures as ordinates and the effective output as abscissæ, by making use of the steam consumption at various loads and constant speed. From the specific steam consumption in kgr. per effective horse-power-hour, the corresponding steam pressure and the steam temperature, the heat consumption in kgr./calories per effective horse-power-hour is then obtained by making use of steam tables, and is plotted against the effective output (fig. 24). As a check the heat consumption at various loads can be plotted again with the speed as abscissæ. This method gives a ready indication of any mistakes since these will cause irregularities in the shape of the curves for constant output. Moreover,

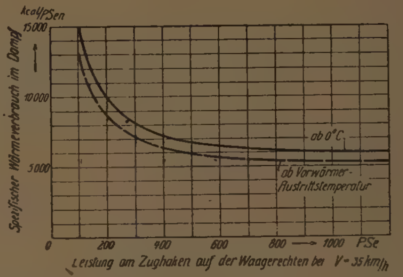

Fig. 24. — Heat used in steam for G 8² locomotive No. 56 2131 at a speed V = 35 km. per hour.

Explanation of German terms:

Ab 0° C = From 0° C. — Ab Vorwärmer-Austrittstemperatur = From temperature at delivery of preheater. — Leistung am Zughaken auf der Waagerechten bei V = 35 *km/h* = Output (effective H. P.) at draw hook on the level at a speed of V = 35 km. per hour. — Spezifischer Wärmeverbrauch im Dampf = Specific heat consumption in steam.

it shows which is the best speed of the locomotive at any output. The determination of the heat used in the steam is essential for judging various locomotives, because the steam pressures in the boiler may vary from 12 to 120 atm. (170.7-1 707 lb. per sq. inch) and the steam may be saturated, or superheated up to 450° C. (842° F.), and within these limits the heat content of steam varies very considerably.

From the heat content of the total steam generated and the calorifc power of the coal used, the boiler efficiency is arrived at, and this is plotted against the steaming performance (fig. 25) in order that a comparison between all locomotive boilers can be made on a common basis.

The hauling capabilities of locomo-

tives have been determined by carrying out tests at the limiting capacity of the boilers. The values of specific steam consumption in kgr. per effective H. P.-hour at the different speeds at which

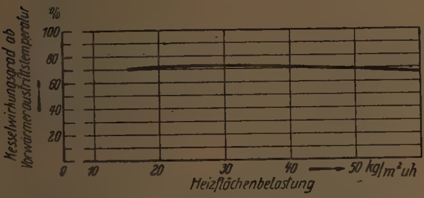

Fig. 25. — Boiler output of G 8² locomotive No. 56 2131.

Explanation of German terms:

Heizflächenbelastung... = Steaming performance, kgr. per sq. metre of heating surface per hour. — Kesselwirkungsgrad ab Vorwärmeraustrittstemperatur = Boiler efficiency from temperature at delivery of preheater.

these tests are run, are plotted against the speed and a curve drawn; this is necessary because the observed points become rather dispersed due to weather conditions, and further it is not always possible to secure a steaming performance of exactly 57 kgr. per m² per hour (fig. 26). The curve of limiting boiler performance, or output characteristic, is obtained from this steam consumption curve by using the formula

$$\frac{\text{H. 57}}{\text{kgr. per effective H. P. per hour.}}$$

where H is the area of the evaporating surface, fire side. The corresponding values of tractive effort *Ze* at the drawbar are obtained from

$$\frac{\text{Ouput in effective H. P.} \times 270}{\text{Speed km./hour}}$$

At low speeds the friction between wheels and rails governs the magnitude of the tractive effort rather than the boiler, and since it is difficult to obtain these figures of tractive effort accurately by tests, in view of the many accidental circumstances that influence the friction, they are calculated from the formulæ

$$Ze = Zr - \left(2.5.Gt + 6\left(\frac{V}{10}\right)^2\right)$$

and $$Zr = Gr.C$$

in which :

Zr is the tractive effort at the circumference of the driving wheel in kgr.;

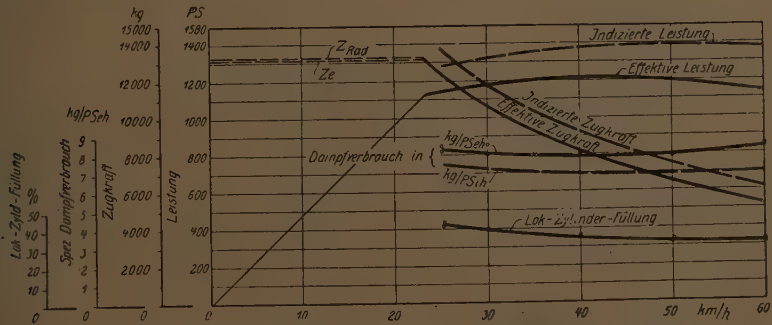

Fig. 26. — Output characteristic of G 8² locomotive No. 56 2131.

Explanation of German terms:

Leistung = Output. — Lok. Zyl. Füllung = % cut-off. — Spez. Dampfverbrauch = Specific steam consumption. — Z Rad = Tractive effort at wheel rim. — Ze = Effective tractive effort.

Gt is the total weight of the locomotive with the tender 2/3 filled, in metric tons;

Gr is the adhesive weight in metric tons;

V is the speed in km. per hour;

C is an assumed constant, for :

3-cylinder engines, 204 kgr. per ton;

2-cylinder engines, 197 kgr. per ton.

A report is drawn up on the tests carried out on any locomotive and this includes a tabulated summary of the observations, the deduced quantities in the form of curves as described above, and any explanatory remarks considered necessary. Any special points or incidents noted during the test are recorded together with suggestions for improvements. These reports are used in the Central Locomotive Design Department of the Reichsbahn as the basis of new designs and act as an incentive for the improvements of existing motors.

The preceding remarks have described the apparatus and methods of the Locomotive Experimental Department as they exist at the moment. In these times of rapid changes, when every day brings new discoveries, the procedure in experimental work has often to be modified; new types may require new methods of treatment or the work may have to be directed into new channels, as for example investigations into oscillation phenomena, higher speeds or other different working conditions.

Moreover, measuring apparatus is continually being improved, and every development in this field has to be followed up and turned to account where it can increase the accuracy of measurement and enable untried arrangements to be established as practicable.

Testing equipment for locomotives and rail motor vehicles.

Introduction.

A fixed plant for stationary tests on locomotives and rail motor vehicles has been installed as part of the Locomotive Experimental Department's installation at the Reichsbahn repair works at Grunewald. The scientific experimentation of steam and Diesel locomotives and of rail motor vehicles, which hitherto was confined to tests on the track, could thus be made more complete and extended in scope. The installation had been under consideration for some years, but its construction had to be repeatedly postponed mainly owing to the adverse postwar conditions. The original plan of building a locomotive testing equipment for experiments on locomotives with up to six driven axles, with a loading of 25 tons and a separate rail motor vehicle testing equipment, had to be abandoned for economic reasons. A combined equipment for both classes of vehicle was put into service on 17 June 1930; it was designed by the Experimental Department on principles approved by the Central Locomotive Designing Department of the Reichsbahn (fig. 27).

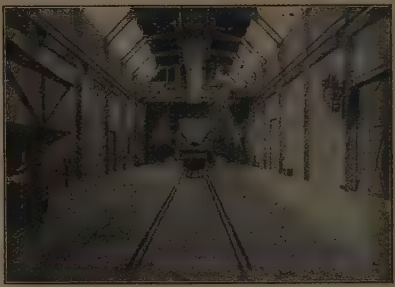

Fig. 27. — General view of experimental station for locomotives and rail motor vehicles.

Previously, the investigation of locomotives and rail motor vehicles had been carried out solely by test runs with instrument coaches, and these runs had to be as long as possible under steady conditions, *i. e.* with constant effective output and speed, since this is essential in locomotive testing if measurements are to be obtained that have any comparative value. The maintenance of a steady state over a long run depends, however, on many external influences, some of which it is difficult if not quite impossible to mitigate. There is no sufficiently long test section laid perfectly horizontal and straight, which would allow a test run to be carried out with a steady set of conditions throughout. The experimental figures and their value for comparing one set of results with another are affected by every variation in weather; by the wind strength and direction, atmospheric temperature, rain, snow, etc. Also to an even greater extent by the resulting variation in the frictional resistance between rails and wheels, such as occurs, for example, from the fall of leaves in autumn. An additional factor is that, on routes where there is a busy service of trains, the test runs cannot be carried through entirely free from interference and must be fitted into the service time table. There is always a risk that the test train may find a signal against it with the result that the test is rendered valueless.

None of the disturbances referred to, affects tests carried out with the stationary testing plant, because the engine or other vehicle is in an enclosed space and works under perfectly steady conditions. Moreover, the duration of a test can be made much greater than is possible with track tests, especially in the case of boiler tests, the only limitation being the necessity of cleaning out the fire. Tests that cannot be carried out on a travelling engine can be made reliable with the fixed equipment; examples of such tests are valve gear operation, determination of the quantity and composition of the soot that is ejected, of the unburned ash, and similar special investigations.

It must be pointed out, however, that tests on the fixed plant are only comparable amongst themselves and a straightforward comparison cannot be made between their results and those carried out on the track under entirely different conditions. For example, a locomotive on the fixed bed will give a greater effective output at the draw-bar than when running in front of a test train on the track; in the first case it has only its own mechanism to drive, and there is no frictional resistance of the carrying wheels of engine and tender, or the by no means insignificant wind resistance to be overcome.

The thorough and comprehensive investigation on the fixed bed of the performance of engines and rail motor coaches is very valuable, but such tests cannot altogether do away with the necessity of running tests under conditions approximating to practical service, not only by reason of the special conditions of stationary tests, but also because there are certain kinds of tests that can only be made on the road. Consequently the experimental results obtained on the test bed have to be supplemented by running tests using the instrument coach.

The main principles that governed the design of the testing equipment in question were as follows :

« It has to be suitable for testing steam and Diesel locomotives and rail motor vehicles of 1 435-mm. (4 ft. 8 1/2 in.) gauge. Its dimensions and the strength of the loaded portions have to be such that tests can be made on locomotives with up to 5 coupled axles having a loading of 20 tons each. Suitable provision has to be made to enable the tractive effort measuring instruments of the instrument coaches to be calibrated on the test bed.

The maximum speed that can be

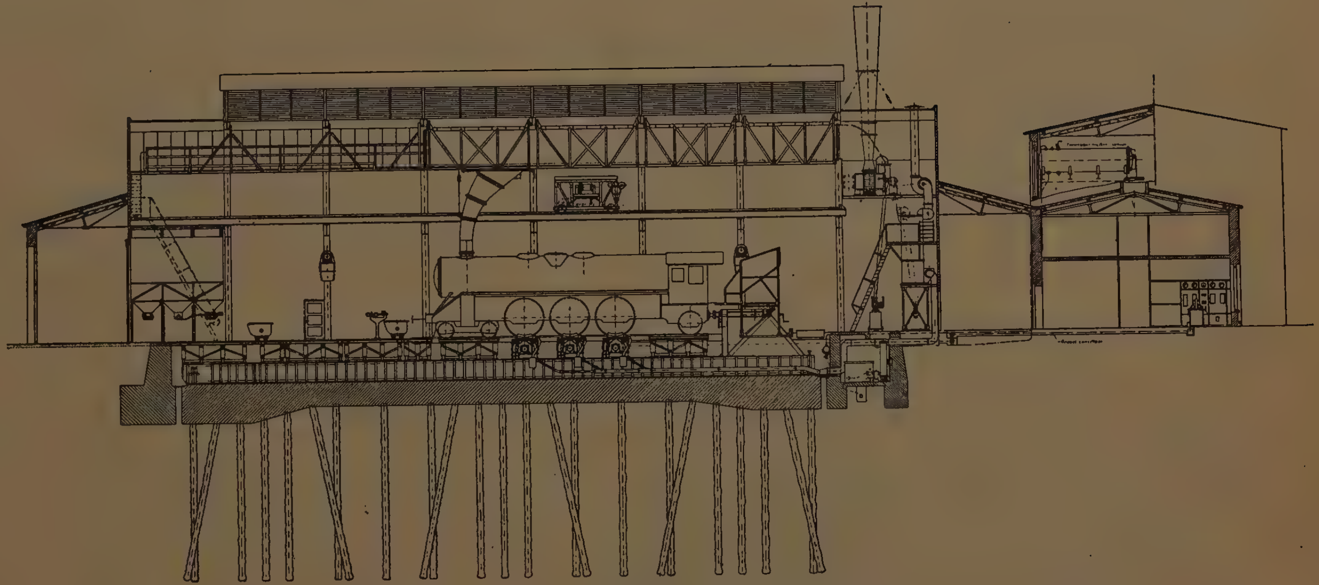

Fig. 28. — Longitudinal section of experimental station for locomotives and rail motor vehicles.

reached on the test bed is fixed at 100 km. (62.1 miles) per hour.

Before proceeding to describe the equipment in detail the method of operation and general layout will be explained.

The locomotive to be tested is provided with the same fittings, instruments, and electric leads as are required for tests on the track. The ordinary draft gear is replaced by a stronger gear suitable for connection to the anchoring arrangement provided, and the locomotive is then hauled on to the special mounting gear by means of a winch, coupled to the draw-hook block and set on the braking units. It has to be adjusted so that the driving axles are exactly over the centre of the bearing rollers of the braking unit. The chimney is connected to the smoke flue by trunking and the feed water and electric cable connections made.

When the preparations have been completed, the engine is driven in the same way as on the track, the driving wheels running on the bearing rollers of the braking units instead of on rails. By bringing the adjustable water brakes into operation, resistance is opposed to the rotation of the wheels of the engine and the latter is subjected to a load which would otherwise be used to draw a train. The measurements which are taken in an instrument coach in the case of a running test on the track are carried out in exactly the same way and are transmitted to an instrument room outside the test shed.

So far the test bed has been equipped with three braking units; the designs cover an ultimate extension to five units.

The auxiliary equipment required for carrying out the experimental work can be seen in figures 28 and 29. This includes the smoke removal and soot separating plant, coaling equipment consisting of bunker, weighbridge, and electric travelling crane, feed water supply and measuring tanks, central oil purifying plant, refrigerating plant and oil pumps for coaling down and lubricating the braking units, the latter equipment being placed in a pit connected with the test bed pit. In addition there are sand-

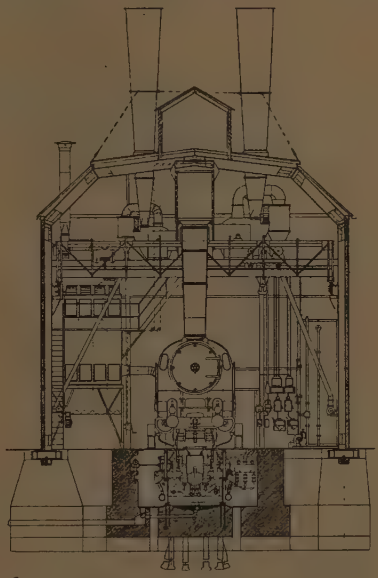

Fig. 29. — Cross section of experimental station for locomotives and rail motor vehicles.

ing, sand removal and filter plants, and situated in an adjoining building, the hydraulic power plant for the brake units.

The buildings.

A new building had to be erected since the head-room in the general testing hall was not sufficient to permit the installation of the test bed for locomotives and rail motor coaches. It was possible, therefore, to design a building laid out so as to meet the special requirements of the equipment. It is a steel-frame structure 41 m. (134 ft. 6 in.)

long, 11.50 m. (37 ft. 9 in.) wide, and 11.20 m. (36 ft. 9 in.) high to underneath the roof trusses, and is of sufficient strength to carry the crane loads, the staging carrying the smoke removal and soot separating plant, the smoke duct that is suspended from the centre of the roof, and a 20-ton steel coal bunker.

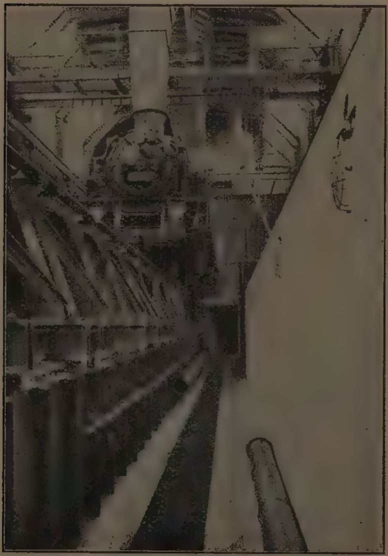

Fig. 30. — Foundation frame and apparatus for bringing locomotive into position.

In order to reduce noise disturbance, the enclosing walls are built of filling panels reinforced with strip iron and are thus adequate to withstand such vibration as may occur. A clerestory runs practically the whole length of the roof and contains louvres for admitting the considerable quantity of air required for combustion in the locomotive firebox, the air flowing directly from outside to the ashpan without passing over the gangways that run along both sides. Ample lighting is provided by roof lights.

Special attention was paid to the form and construction of the foundations of both the buildings and the test bed. No experience was available as to the effect on the foundations and on the surrounding land of the vibrations caused by a stationary locomotive working at the equivalent of 100 km. (62.1 miles) per hour, with its unbalanced, reciprocating masses.

Preliminary borings showed that the subsoil was pure sand. In order to prevent the vibrations reaching the neighbouring buildings and to damp the noise, the main foundation of the test bed itself is separated from the foundations of the enclosing walls and those supporting the hall, connected to the latter, by a wide air space (fig. 30).

The rigidity and safety of the structure that carries the weight of the test bed have been fully assured. The foundation block is built with particularly strong reinforcement and supported by 46 vertical and slanting reinforced concrete piles; moreover, its mass is very considerable, the dimensions being : length, 33.30 m. (109 feet), width, 3.00 m. (9 ft. 10 1/8 in.), depth, 1.20 to 2.00 m. (3 ft. 11 1/4 in. to 3 ft. 3 3/8 in.).

The foundations of the shed walls are carried to the same depth as that of the test bed in order to avoid any danger of the former settling.

An iron frame extending the whole length of the foundation is mounted on the latter to form a convenient support and a uniform means of fixing the braking units and the structures which enable the locomotive to be brought on to them, both of which have to be adjustable to any position to suit the axle centres of the vehicles under test. One end of the foundation frame is constructed to form the so-called anchor frame which embodies a strong rectangular framework to carry the tractive effort

measuring device; provision is made for adjusting the latter vertically to suit the height of the draft gear on the various tender locomotives to be tested (fig. 31). The foundation frame consists of two riveted I beams with ample cross-bracing; it is designed to distribute the weights of the braking units and the locomotive axle loads uniformly over the greatest possible length of the foundations, and to absorb the bending moment due to the pull exerted on the draw hook anchor frame so that only a small part is transmitted to the foundation through the main anchorage.

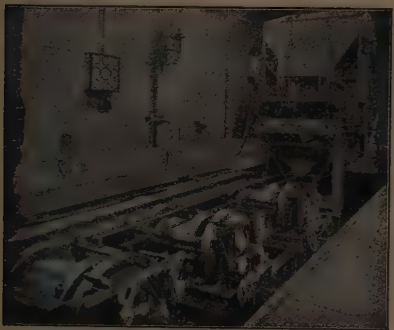

Fig. 31. — Draw hook anchor block, dummy tender and ash removal equipment.

The front cross member of the supporting frame forms a buffer beam for the attachment of buffers to suit both tender and tank locomotives, whilst the rear cross member which supports the tractive effort measuring device and is connected to the main and auxiliary couplings, has to withstand the whole pull of the locomotive (fig. 32).

Arrangement for bringing locomotive into position.

In order to bring the test locomotive into position on the test bed and to mount it on the brake units, the pit contains an auxiliary foundation frame or mounting device. It comprises a number of separate frames or bridge units each of 1.50 to 3.00 m. (4 ft. 11 in. to 9 ft. 10 1/8 in.) long, assembled with the braking units to correspond with the wheel arrangement of the particular locomotive under tests; the whole is bolted in position.

The individual units of the mounting device are of two types. In type A (fig. 32) there is a base frame and a rigid superstructure to the top of which standard rails are welded. The rail height corresponds exactly to that of the track

Fig. 32. — Apparatus for bringing locomotive into position. A-type unit.

into the shed and the gauge is 1 428 mm. (4 ft. 8 1/4 in.). The A-type frames butt directly on to one another at the approach end of the test bed so as to form a continuous track.

Type B frames (fig. 33) also have a base frame, and similar rigid superstructure and standard rails, but have in addition a transverse frame that rests on from four to eight hydraulic pistons.

Across the transverse lifting frames of several of the B frames and passing over the braking units, which are equipped with similar lifting arrangements, are two inner rails of suitable length for

the locomotive; these rails in a manner similar to those used on weighbridges where the track is not interrupted, bear against the inner side of the wheel flanges and guide the locomotive wheels by means of angle pieces.

Fig. 33. — Apparatus for bringing locomotive into position. B-type unit.

To bring the engine into position on the test bed it is first run over the A-type frames running normally on the crown of the wheels. In passing on to the first B frames the wheel flanges mount the inner rails which have previously been raised 5 mm. (3/16 inches) above the outer rails, and the locomotive thus runs on to the remaining frames and the braking units. When the locomotive is in the correct position the inner rails are lowered 70 mm. (2 3/4 inches) by releasing the pressure from the pipe line that serves all the lifting cylinders with oil under pressure. The locomotive driving wheels are thus brought down on to the carrying rollers of the braking units and the idle wheels on to the outer rails of the B type mounting frames (fig. 34).

This design of a continuous inner rail that can be raised and lowered permits the separate braking units and the individual B mounting frames to be bridged over in a simple manner in spite of any adjustment in their positions to suit different locomotives. With only twelve mounting frames having an aggregate length of 29 m. (95 ft. 1 3/4 in.) a suitable mounting arrangement can be assembled in the 24-m. (78 ft. 9 in.) test pit for any German locomotive or rail motor coach.

The locomotive that is running on the test bed is allowed a small movement in both directions of about 5 mm. (3/16 inch) and the idle wheels must of course have the same movement. But the bearing friction due to these small movements is abnormally high and might cause errors in the measurements, and it is therefore necessary to provide rollers with ball bearings for the rails of the

Fig. 34. — Apparatus for bringing locomotive into position. Bridging the braking units.

Fig. 35. — Braking unit seen from the measuring apparatus side.

B-type mounting frames in order that a 5 mm. to and fro motion can be made with freedom.

Auxiliary equipment for the mounting arrangement comprises the hauling gear with its winch, snatch block and hauling rope, and the high-pressure pump for 120-atm. (1 707 lb. per sq. inch) oil pressure.

The braking units.

These are the most important items of the equipment and are shown in figures 35 and 36. They were constructed by the « Germania Werft » of Kiel, in accordance with the design of the experimental department. Each consists of a structural steel frame supporting the bearings for a pair of carrying rollers fixed to an axle, an hydraulic Froude brake suspended on the axle between the wheels, and two alternative sets of gearing having a ratio of 1 : 5 and 1 : 2.53, either of which can be brought into use as desired.

The carrying rollers are of the spoke wheel type with the spokes cased on both sides and with shrunk-on tyres. The inner edges of the tyres are finished to a radius of 14 mm. (9/16 inches) corresponding to the rail profile and the running faces are turned slightly conical with an inclination of 1 in 20. The gauge is 1 428 mm. (4 ft. 8 1/4 in.) in order to limit the side-to-side movement of the engine.

The incorporation of two sets of gearing was rendered necessary on account of the type of brake decided upon. A small high-speed geared brake that could be fitted between the wheels was preferred to a large slow-running hydraulic brake for direct connection, which would have had to be fixed outside the running wheels. The former design avoids one-sided and irregular stresses on the wheels and foundations; moreover, it permits the test pit to be made considerably narrower and by virtue of its smaller size renders it comparatively easy to move the braking units from one position to another.

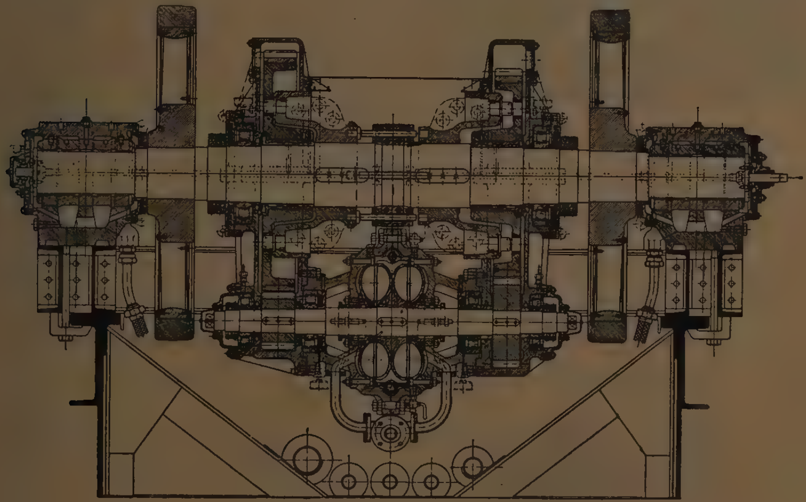

Fig. 36. — Braking unit. Sectional view.

The power produced by the locomotive and transmitted to the carrying rollers and thence through one of the gears to the brake shaft is dissipated in the hydraulic brake and converted into heat.

The hydraulic brake consists of a casing that encloses an impeller keyed to the brake shaft. This runner or impeller has a groove or trough in each face that is divided into a number of separate pockets or small buckets by radial partitions or vanes. The two halves of the casing are constructed with a corresponding number of similar pockets. Water at a pressure of 3 atm. (42.7 lb. per sq. inch) is led into the brake through holes in the partitions between the casing pockets.

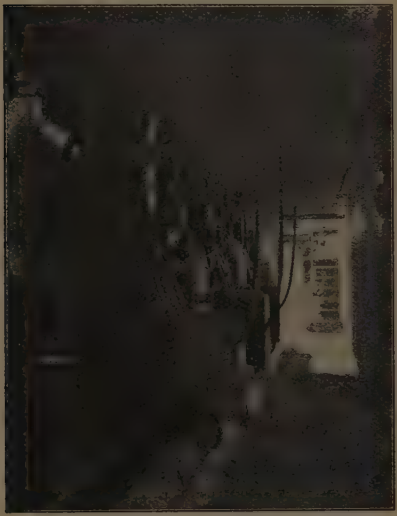

Fig. 37. — View of gangway during tests.

The rotation of the runner at high speed causes the water to be thrown towards the periphery of the casing until it is diverted towards the runner again by the stationary pockets. When the fixed and stationary pocket are opposite one another the water embraced in each pair forms an elliptical whirling mass and further rotation causes the vanes of the runner to cut the water rings and this action produces the hydraulic resistance (fig. 37).

The braking effect is controlled by a valve gear fitted to each unit. The work absorbed by the brake is measured by mounting the casing on trunnions so that it hangs from the axles of the carrying wheels. A lever which bears against an hydraulic pressure measuring device enables the torque to be measured by the indications of a manometer which shows for each brake the force in kilogrammes which it is absorbing.

Whereas locomotive testing equipments in other countries use brakes of the friction type exclusively, the installation now described is the first in which use has been made of an hydraulic whirl brake. This type of brake has a wide range and is easily controlled. As will be seen from the diagram figure 38, a braking effect can be obtained on each axle of 300 effective H. P. at the comparatively low speed of 22 km. (13.7 miles) per hour, while at 100 km. (62.1 miles) per hour it may be varied from 40 to 1 400 H. P. Another advantage is the great flexibility of the braking action, so that it is impossible to brake the carrying wheels so hard that the locomotive wheels slip even if the braking force reaches the adhesion limit between the wheels of the locomotive and the brakes. Before a pair of braking wheels can be brought to a standstill a small reduction of the speed must occur, and since the braking action varies considerably with the speed this is sufficient to reduce the braking effect.

The provision on each unit of a speed indicator and a manometer for measuring the braking force permits not only close control and uniform adjustment of all the brakes, but also the measurement of the output from each axle of the loco-

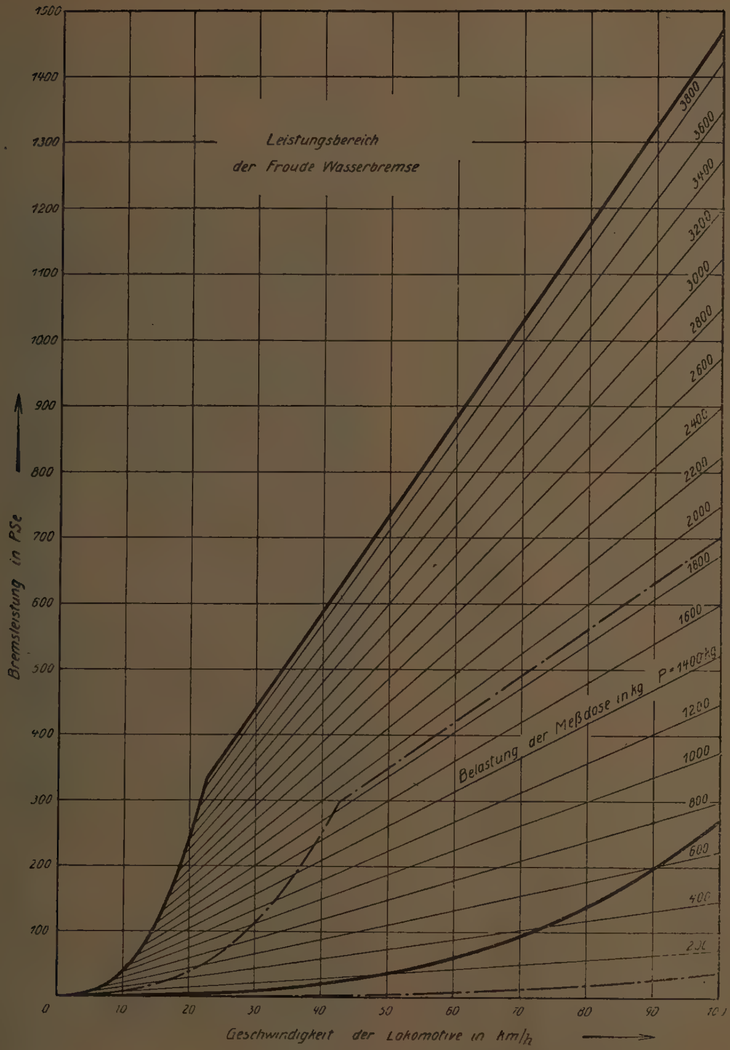

Fig. 38. — Braking diagram of an hydraulic brake.

Range with 1 : 5 reduction gear.

Range with 1 : 2.53 reduction gear.

Explanation of German terms:

Belastung der Messdose = Load on measuring instrument box. — Bremsleistung in PS e = Braking power in effective H. P. — Geschwindigkeit der Lokomotive in km/h = Speed of locomotive in km. per hour. — Leistungsbereich der Froude Wasserbremse = Range of Froude hydraulic brake.

motive; this is the first equipment that has enabled this to be done.

The braking units, which together with the mounting frames are simply bolted to the upper member of the foundation frame, can be assembled for a minimum wheelbase of 1 420 mm. (4 ft. 8 in.) between axle centres. They are moved by means of a 10-ton overhead crane.

The water for the brakes has to be delivered under a constant pressure of 3 atm. (42.7 lb. per sq. inch). In the absence of a suitable water tower it was necessary to instal a special hydraulic pressure plant. There are two closed tanks, each of 5.2 m³ (184 cubic feet) capacity, connected together by equalising pipes, and these are supplied from the mains of the Grunewald repair shops at a pressure of 4 to 7 atm. (56.9 to 99.6 lb. per sq. inch). A float valve in the tanks maintains the water level at about 60 % of the full capacity, so that a constant volume of water is available at 0 atm. pressure. By admitting air at a pressure of 3 atm. (42.7 lb. per sq. inch) to the tanks water at a constant pressure is supplied at the desired points; the elasticity of the air in the container ensures a uniform pressure whatever the rate at which the water is drawn off.

The lubrification of the main bearings, the gearing and all parts that do not run in ball bearings is effected by oil pumps in conjunction with a filter and refrigerator. The oil is drawn from a storage tank and delivered into the main oil pipe through a filter and water cooler at a pressure of 4 atm. (56.9 lb. per sq. inch). It flows through all the braking units in series, and then flows back to the tank through a common return pipe.

Sand and sand removal equipment.

This is another auxiliary forming part of the braking equipment. It is impossible to prevent water and oil getting on to the running surfaces of the carrying wheels during the tests and in order to keep the friction constant between them and the locomotive wheels, especially during tests at heavy loads, the surfaces have to be periodically roughened. The sanding gear on the locomotive is not suitable because it distributes the sand too much and might cause sand to get into the bearings of the braking

Fig. 39. — Sanding and sand removal equipment. Dust aspirator removed.

units. For this reason the sanding equipment shown in figure 39 has been installed.

A sand box is fitted in front of each driving wheel and provided with a fine-adjustment ejector operated by compressed air and connected by a down-pipe to the dust guard, figure 40. This guard is fixed at rail height to the bearer that carries the flooring and surrounds the lower part of the engine wheel and

the upper part of the carrying roller. The sand pipe, with a nozzle at the end, terminates in the guard immediately in front of the point where the wheels touch. In a line with the nozzle is the dust receiver which has a pipe connec-

Fig. 40. — Sand aspirator.

tion from which a short pipe leads to the coarse sand separators that are fitted on both sides of the braking unit. These separators remove the larger particles from the mixture of air and sand and prevent choking of the long suction pipe; the main piping has therefore to carry only the fine sand. Where the pipes run along the foundation frame

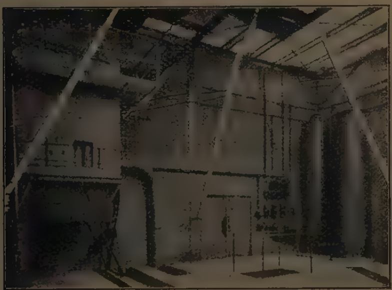

Fig. 41. — Filter with suction pipe. Feed water measuring tank. Drop pipe from cinder separating plant.

they are made telescopic in order that they can be adjusted to the varying distances apart of the braking units to suit different locomotives; elsewhere rigid piping is used.

The cellular filter that is fixed to the wall of the shed behind the locomotive (fig. 41) has a total filtering surface of 59 m² (635 sq. feet) and comprises 32 tubular cells arranged in four separate compartments. An automatic cleaning device driven from the exhauster motor agitates the filter cells and at the same time a current of air is applied in the opposite direction. The filter can thus be cleaned while it is in use and the sand falls into a screw conveyor which discharges into a receiver.

Verticality testing apparatus.

The running of a locomotive on the test bed and the accuracy of the tractive effort measurements are considerably affected if the driving axles are not in an exactly vertical line above the axles of the supporting rollers on the brake units. Before the locomotive is

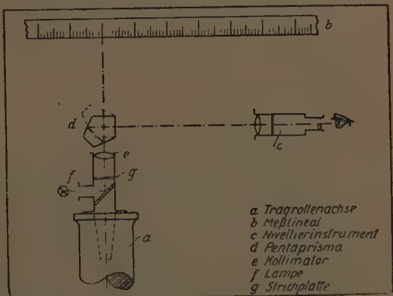

Fig. 42. — Apparatus for ensuring verticality Diagram illustrating the principle.

Explanation :

a = Axle carrying supporting rollers.
b = Scale.
c = Levelling instrument.
d = Five-sided prism.
e = Collimator.
f = Lamp.
g = Plate carrying index line.

brought into position the brake units have to be accurately adjusted so that all the axles are exactly parallel to each other and the spacing is exactly the same as that of the locomotive driving axles. It is a somewhat difficult matter to obtain the necessary accuracy with simple apparatus and the optical device, as shown in figure 42, was therefore designed. It consists of a levelling instrument fixed to the head of the pit, a collimator and five-sided prism for mounting at the centre of the axle of the braking unit, and an accurately divided scale that is let into one side wall of the pit at the height of the axle centres; this scale extends 23 m. (75 ft. 5 1/4 in.) from the buffer beam of the anchor block. It is not possible to describe the apparatus more fully in this article, and the following remarks deal only with the method of using it.

The collimator is fitted into an accurate conical seating in the axle of the particular braking unit that is to be adjusted, and its optical axis is therefore an extension of the shaft carrying the supporting rollers. A beam of light from the collimator lighted inside impinges on the prism in position I and is thereby deflected through 90°. If the brake unit is in the correct position the beam must then enter the levelling instrument at the center of the hair-cross. If the prism is now turned through 90° to position II, the beam — which formerly took the path — collimator, prism, levelling instrument, is deflected once more through 90° and forms another extension of the optical axis of the collimator which is projected on the scale. The scale reading can them be read through the levelling instrument — which has not been moved — and indicates the position of the braking unit longitudinally. By setting all the braking units at the correct distance apart in this manner, the second requirement which the apparatus has to fulfil, is also complied with, namely to set all the axles parallel to each other; this results automatically from setting the axis of each braking unit exactly perpendicular to the fixed optical axis of the levelling instrument by the aid of the five-sided prism.

Crane equipment.

An overhead travelling crane is installed for moving the braking units and mounting frames into position, and in order to reduce the overall height of the shed to a minimum the main 10-ton crab is mounted within the crane girders. An auxiliary crab, consisting of a 1.5 ton travelling electric pulley block is provided for coaling the test locomotive, and a gangway is arranged in the crane girders for obtaining access to the smoke duct and the travelling smoke hood.

Fig. 43. — Express locomotive S 35 17 (S 10[1]) on the test bed (planking removed).

Smoke removal and ash separating plants.

In designing the arrangements for conducting away the products of combustion it was necessary not only to ensure complete removal of the mixture of steam and smoke emitted by the chimney, but also to separate to the maximum extent possible any unburnt particles of fuel and dust. The second requirement was laid down in order to permit the

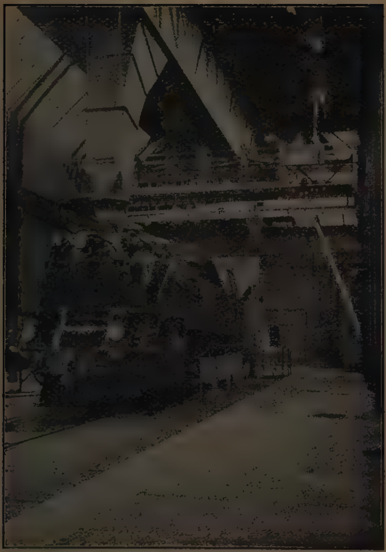

Fig. 44. — Standard locomotive Pt 35 15 (series 64) on the test bed.

investigation of the volume and composition of the solid ejected material which is only possible when carrying out tests with the locomotive stationary.

The mixture of steam and smoke is drawn from the engine chimney through the hood and duct suspended over the centre of the track and passes into the separating plant.

The smoke duct is 1 800 mm. (5 ft. 11 in.) high and 1 400 mm. (4 ft. 7 in.) wide and has an internal cross section of 2.50 m² (26.9 sq. feet). It is constructed entirely of steel and designed in such a way that the surfaces inside the supporting and stiffening framework that are in contact with the steam and smoke can easily be replaced.

As the smoke hood has to suit locomotives of different lengths, and to enable it to be connected to any point of the lower part of the duct, this part is made of overlapping plates 50 cm. (19 11/16 inches) wide, and these are fixed by thumb screws; this construction gives a tight and flexible arrangement. The channel irons which form part of the framework on the underside of the duct are used as a track for the sliding hood. They are continued under the gangway that joins the smoke duct, right up to the end wall of the shed, which contains the main entrance, so that the hood can be moved out of the way if the crane has to be used near the entrance end (fig. 44).

The smoke hood consists of a funnel mounted on a carriage, and having a cross section that increases from 0.50 m² (5.3 sq. feet) at the circular inlet to 2.50 m² (26.9 sq. feet) at the upper end where it is rectangular. It is connected to the duct by two easily fitted closing pieces. The hood is curved backwards so that the gases have a smooth flow from the engine into the horizontal duct. At the front edge of the duct end of the hood there is a hinghed flap that can be operated from outside so as either to close the hood orifice when someone has to enter the duct, or when open at an angle to prevent the steam and smoke from impinging violently on the top of

Fig. 45. — Smoke removal and dust separating plant.

the duct and thereby causing a choking effect. A stout asbestos hose piece forms a flexible but airtight connection between the locomotive funnel and the lower end of the hood.

There was considerable difficulty in deciding upon a suitable dust separating plant, since there is no really serviceable apparatus yet available for cleaning gases at more than 150° C. (302° F.) by a dry process. The more effective wet process which has already been tried out in many installations, could not be considered since the considerable quantity of water required was not available, and there was no space for the necessary settling tanks. Moreover, the separated material could not have been recovered in its original form and would have necessitated a troublesome treatment to render it serviceable for the tests.

The electrolytic process of separation which has also been developed to an advanced stage was put out of court by the high cost of installation, and more especially by the difficulty of preventing flashover of the high-tension electric supply in the cleaning chambers, due to the steam present with the flue gases.

The only course that remained was to reconsider the dry process and to discover which of the many available systems was most suited to the extreme variations of duty that occur in carrying out the tests.

The choice fell on a smoke extraction and dust separating plant on the Prat-Daniel system, illustrated in figure 45, as the information collected showed that this type had so far achieved the highest efficiency of any dry separating plant. It consists of two turbo-separator units, one twice as large as the other, with a total suction capacity of 60 000 m³ (2 118 885 cubic feet) of hot gases per hour. The mixture of steam and smoke is drawn from the duct by two twin-inlet turbo-exhausters connected one on each side of the outlet piece formed by an extension of the duct. The gases are projected against the outside casing of the exhauster with a velocity of about 50 m. (164 feet) per second. The turbo-exhausters differ from ordinary designs in having a spiral semi-circular extension in which the whirling gases are retained for a sufficient time for the solid particle to be thrown outwards by centrifugal force so as to be concentrated in the layer of gas nearest the wall of the casing. This dust-laden part of the gases is tapped off through a regulating shutter and passes to a cyclone separator; the cleaner gas forming the inner layer is diverted directly to the chimney. The gas that has passed through the cyclone is led back to the exhauster in order that any dust still remaining in it may be finally separated by the powerful centrifugal effect.

The dust separated out in the cyclone and the coarser particles that have been previously deposited in the duct are discharged through pipes and dust guards into small hopper wagons and eventually weighed together with the ashes from the locomotive smokebox. As such data is not obtainable on track tests it gives a valuable insight into the volume and composition of the unburnt particles thrown out from the locomotive when running.

It is important that the exhausting plant should not produce additional draught or create a back pressure which would influence the proper function of the blast-pipe in regulating the rate of combustion on the engine grate, and the plant has accordingly been subdivided in such a manner as to bring this effect under control. In order to combine such control, with the requirement of always running the turbo-exhausters at maximum speed to obtain the most effective centrifugal effect, the full capacity of the exhausting plant which is rarely required had to be divided into two self-

contained units. The smaller unit is capable of dealing with the exhaust from locomotives up to 700 effective H. P., and the larger unit with outputs up to 1 500 effective H. P. More powerful engines necessitate running both of the exhausting plants together. For very small or intermediate outputs the draught can be regulated by dampers fitted to the inlets to the fans.

Coaling plant.

A special coaling plant had to be installed inside the test shed for coaling the locomotive under test. It consists of a bunker having a capacity of 20 tons,

Fig. 46. — Coal bunker.

a number of delivery trucks, and a weighing machine incorporated in the track. The plant is so arranged that the coal has to be transferred by hand only once, namely from the railway trucks into the bunker; it descends through chutes provided with a simple means of regulation, into the trucks; these are weighed on the way to the locomotive and are then hoisted by the auxiliary crab running on the frame of the overhead crane, and emptied into the tender (fig. 46).

When a tender locomotive is to be tested, the tender is uncoupled as the play between the two would introduce some risk in operating the test equipment; the dummy tender erected above the anchor frame is used instead (fig. 31). This substitute is adjustable in height to suit the different heights of locomotive foot plates. Unlike the locomotive tender on which the water tank takes up most of the available space, the dummy tender has accommodation for coal only, together with half a footplate and driver's cab.

Feed water supply.

Feed water for the locomotive on the test pit is taken directly from the measuring tanks in the shed (fig. 41) through a permanent pipe terminating under the substitute tender in a connecting piece to which the locomotive feed water connections are coupled.

The tanks have a capacity of 5 m³ (1 100 Imp. gallons) each, and they are connected to the feed main in such a way that one is being filled while the other is available for supplying the locomotive. Gauges extending the full height permit continuous observation of the rate at which water is being drawn off by the test engine.

Fire cleaning device.

The final item of the auxiliary equipment to be described is the provision for cleaning out the fire. A locomotive may remain on the test pit for several weeks, and therefore arrangements are necessary for removing the remains of the fire after each test run.

Two ash wagons were constructed of

suitable dimensions for passing through the very restricted space between the locomotive frame and the braking units, and these can be pushed under the ash pan (fig. 31). The clearance required for the wagons is provided also in the draw hook anchor frame and the wagons can be run thus to the back of the tender and then lifted by the crane and emptied.

Fig. 47. — Instrument room. Instrument desk and temperature indicating equipment.

Measuring equipment.

The necessary measurements required for investigating the output and economy of the locomotive under test are taken partly in the cab, and partly by automatic recording charts installed in a separate instrument room and remote-operated by mechanical, electrical, or hydraulic transmission. A mechanical system coupled to one of the braking units transmits the necessary motion to the chart strips through a gear box and suitable gear trains, and the charts are thus driven at a speed proportional to that of the engine in the ratio of 150 or 300 mm. per km (8.2 to 16.4 inches per mile) run. The charts record the speed in kilometres per hour, the tractive effort in kilogrammes, the time in seconds, the distance covered in kilometres and the feed water consumption in units of 50 l. (11 Imp. gallons) (fig. 47).

The tractive effort exerted on the draw hook anchor frame is measured by a hydraulic device fixed to the frame and having three ranges; according to the setting of the plunger area, it measures up to 3 000, 15 000 or 35 000 kgr. (6 600, 33 000 of 77 000 lb.). The hydraulic pressure from the measuring device is transmitted through a pipe to the indicating and recording manometer fixed in the instrument room.

An automatic recording planimeter is connected to the stylus of the tractive effort recorder and the movements of its driving wheel are proportional to the distance run while the movements of the index roller are proportional to the tractive effort. By reading the index and applying the correction factor of the instrument the total work done is at once obtained.

The speedometer on the bench in the instrument room and the tachometer above it are driven from a gear box,

Fig. 48. — Instrument desk and case containing driving equipment.

but the three speedometers on the wall are each operated from an electric emitter driven from the three braking units and thus give the speeds of the respective carrying rollers; the last mentioned instruments were installed for use when testing vehicles with driven axles that are not coupled, and they enable the uniformity of speed of the axles to be checked (fig. 48).

The feed water evaporated in the locomotive is measured by means of the vertical tanks installed in the shed and by a meter in the delivery pipe to the boiler. The volume of water flowing through the meter is transmitted electrically to a recorder on the instrument bench and an indication is made for every 50 l. (11 Imp. gallons) used. The coal consumption is ascertained by weighing the coal that is loaded on the tender and samples are taken at intervals for determination of the calorific value.

Temperature measurements are of the greatest importance as regards locomotive tests, and recording and indicating instruments connected to 32 resistance thermometers are accordingly installed in the instrument room (fig. 47).

Two 37-strand cables connect the thermometers that are fitted on the locomotive to the various instruments. In addition to those mentioned above, there are also two indicating instruments for temperature measurements of the exhaust gas of the internal combustion engines of Diesel locomotives; these are arranged for connection to 12 thermocouples.

The composition of the combustion gases of the test locomotive is investigated continuously. A small quantity of the gas is drawn continuously from the smoke box and a portion is delivered to an electric testing apparatus, of which the indicating instruments for CO_2 and $CO + H_2$ are installed in the instrument room. Another portion of the sample is collected in a rubber bag and is subjected to an average analysis with an Orsat apparatus after the conclusion of the test; this serves also as a check on the automatic electric analyser. Amongst other apparatus fitted in the instrument room are a remote-operated water-level indicator and an automatic signalling device (fig. 49).

Fig. 49. — Operator's panel in the test shed.

An instrument board is fitted in the test shed itself opposite the engine-driver's position in order to give the engineer in charge of the test complete supervision, from one point, over the running of the locomotive and the proper working of the whole plant with its auxiliaries. This board is fitted with two

speedometers, a tractive effort manometer, manometers for the draught in the smoke duct and in the sand removal apparatus, for the pressure of the water supplied to the brake units, the lubricating oil pressure, and the working pressure in the lifting cylinders of the mounting frames; it contains also a remote-operated water-level indicator.

Conclusion.

Since the locomotive experimental station was put into service, tests have been carried out on a 4-6-2 passenger tender locomotive and on a 4-6-0 express engine. The maximum speed attained was 123 km. (76.4 miles) per hour. These tests have shown that the capabilities of the equipment may be regarded as in accord with the specification to which it was designed.

It is anticipated, therefore, that the equipment will in conjuction with the existing stationary test plant of the Locomotive Testing Department, and the dynamometer cars, advance the scientific experimentation of locomotives, and consequently lead to still more economical performance and greater reliability in operation.

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MARCHAND (J.). — Voici les nouveaux **basculeurs** pour décharger les wagons rapidement et économiquement. (2 300 mots & fig.)

Les Chemins de fer et les Tramways. (Paris.)

1931 621 .134.3 (.44)

Les chemins de fer et les tramways, octobre, p. 185.

L'application de la **surchauffe** aux locomotives des chemins de fer d'Alsace et de Lorraine. (1 400 mots & fig.)

1931 625 .231 (.44)

Les chemins de fer et les tramways, octobre, p. 186.

Les **nouvelles voitures** de Banlieue du Paris-Orléans. (900 mots.)

1931 621 .132.8 (.73) & 621 .43 (.73)

Les chemins de fer et les tramways, octobre, p. 187.

Locomotive pétroléo-électrique « Porter ». (3 600 mots & fig.)

1931 621 .132.7 (.44) & 621 .43 (.44)

Les chemins de fer et les tramways, octobre, p. 189.

Locomotive Diesel-électrique de manœuvre pour le Paris-Lyon-Méditerranée. (900 mots.)

1931 621 .134.2

Les chemins de fer et les tramways, octobre, p. 191.

Tiroir circulaire équilibré pour les locomotives à vapeur. (1 400 mots & fig.)

1931 621 .135.2 & 625 .212

Les chemins de fer et les tramways, octobre, p. 192.

Plaque obturatrice en quatre pièces pour fusées. (1 500 mots & fig.)

1931 625 .17

Les chemins de fer et les tramways, octobre, p. 193.

LEGUILLOCHET (R.). — Tendances actuelles dans l'**entretien des voies** et leur action sur l'économie des réseaux ferrés. (4 500 mots & fig.)

1931 621 .135.2 & 625 .214

Les chemins de fer et les tramways, octobre, p. 196.

Dispositif de lubrification des bourrelets de jante. (1 700 mots & fig.)

1931 656 .257

Les chemins de fer et les tramways, octobre, p. 198.

Système d'**enclenchement électrique** « Mors ». (1 200 mots & fig.)

1931 621 .39 & 669 .1

Les chemins de fer et les tramways, octobre, p. 199.

Perfectionnements à la **soudure** des pièces d'acier. (4 000 mots.)

1931 625 .143.3 & 625 .171

Les chemins de fer et les tramways, octobre, p. 203.

Wagonnet pour **inspection magnétique** des rails. (2 000 mots & fig.)

1931 656 .212.5

Les chemins de fer et les tramways, octobre, p. 204.

Installation de dos d'âne pour gares de triage. (1 200 mots & fig.)

1931 625 .143.5
Les chemins de fer et les tramways, octobre, p. 206.
Perfectionnements à la fixation des rails. (1 800 mots & fig.)

1931 625 .11
Les chemins de fer et les tramways, octobre, p. 208.
Plateforme rigide et réglable en béton armé pour le support des voies. (2 000 mots & fig.)

L'Industrie des voies ferrées et des transports automobiles. (Paris.)

1931 621 .33 (06 (.73)
L'Ind. des voies ferrées et des transp. autom., septembre, p. 270.
GIRARD. — Résumé des travaux présentés au 49e congrès annuel de l'American Electric Railway Association, tenu en juin 1930, à San-Francisco. (6 400 mots.)

1931 625 .6 (06 (.44) & 656 .1 (06 (.44)
L'Ind. des voies ferrées et des transp. autom., septembre, p. 9.
VIe Assemblée Générale technique de l'Union des Voies Ferrées et des Transports Automobiles. (Lille, 15-18 juin 1931. — Compte rendu général. (24 000 mots & fig.)

1931 621 .33
L'Ind. des voies ferrées et des transp. autom., septembre, p. 43.
LAURU. — Moteurs rapides de traction. Rapport présenté à la VIe Assemblée Générale Technique de l'Union des Voies Ferrées et des Transports Automobiles. (Lille, 15-18 juin 1931) et discussion. (8 900 mots & fig.)

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1931 656 .257 (.493) & 656 .258 (.493)
Revue de l'Ecole polytechnique, juin, p. 475.
LEMAIR (A.). — La méthode belge de représentation et de vérification des diagrammes d'enclenchements. (4 700 mots & fig.)

Revue générale des chemins de fer. (Paris.)

1931 625 .13 (.44)
Revue Générale des chemins de fer, novembre, p. 328.
BOUVET & GUERARD. — Remise à double voie du souterrain de la Croix-de-l'Orme. (7 500 mots & fig.)

1931 625 .23 (.44) & 625 .26 (.44)
Revue Générale des chemins de fer, novembre, p. 343.
LESCŒUR. — Note sur la transformation des voitures A², B² et A³, en voitures C⁴ et C³, aux ateliers de la Compagnie des chemins de fer de l'Est, à Romilly. (1 400 mots & fig.)

1931 385. (09 (.66) & 385 .113 (.66)
Revue Générale des chemins de fer, novembre, p. 347.
Chemins de fer coloniaux de l'Afrique occidentale française. (7 000 mots & fig.)

1931 621. 43 (.7)
Revue Générale des chemins de fer, novembre, p. 364.
Automotrices et locomotives à combustion interne en service sur les chemins de fer de l'Amérique du Nord. (2 400 mots.)

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1931 656
Revue politique et parlementaire, 10 Novembre, p. 310.
COLSON (C.). — Revue des questions de transport. (5 800 mots.)

Revue universelle des Mines. (Liége.)

1931 621 .116
Revue universelle des mines, n° 9, 1er novembre, p. 286.
JADOT (A. J.). — Note sur le calcul des sollicitations d'une tuyauterie parcourue par un fluide incompressible en régime permanent ou en régime varié. (3 000 mots.)

1931 624 .2 (01
Revue universelle des mines, n° 9, 1er novembre, p. 292.
LAMOEN (J.). — La théorie de la poutre sur fondation élastique et ses applications. (2 000 mots & fig.)

1931 669 .1
Revue universelle des mines, n° 10, 15 novembre, p. 309.
CHEVENARD (P.) & PORTEVIN (A.). — Contribution à l'étude du revenu des aciers trempés. (4 600 mots et fig.) (A suivre.)

In German.

Die Lokomotive. (Wien.)

1931 621 .132.3 (.43) & 621 .132.6 (.43)
Die Lokomotive, Oktober, S. 189.
2-C-2 Heissdampf-Schnellzugs-Tender-Lokomotive der Deutschen Reichsbahn. (1 900 Wörter & Abb.)

1931 621 .13 (09 (.436)
Die Lokomotive, Oktober, S. 192.
HILSCHER (V.). — Lokomotiv-Geschichte einiger kleiner österreichischer Eisenbahn-Verwaltungen. (3 800 Wörter & Abb.)

1931 385. (09 (.47)
Die Lokomotive, Oktober, S. 199.
Das Eisenbahnmaschinenwesen im Fünfjahrplan Russlands. (4 200 Wörter.)

Elektrische Bahnen. (Berlin.)

1931 621 .33 (.431)
Elektrische Bahnen, Oktober, S. 289.
REMY. — Der wirtschaftliche Erfolg der **Elektrisierung der Berliner S-Bahn.** (1 500 Wörter.)

1931 625 .151
Elektrische Bahnen, Oktober, S. 297.
WENDEL (F.). — **Weichenanordnung** bei Stromschienen-Anlagen. (1 000 Wörter & Abb.)

1931 625 .255
Elektrische Bahnen, Oktober, S. 299.
BADER (W.). — Theorie der **Kurzschlussbremse.** (7 000 Wörter & Abb.) (Schluss.)

Elektrotechnische Zeitschrift. (Berlin.)

1931 656 .253
Elektrotechnische Zeitschrift, 43. Heft, 22. Oktober, S. 1333; 44. Heft, 29. Oktober, S. 1359.
KAMMERER (A.). — Die stationären und nichtstationären Verhältnisse bei der **induktiven Zugbeeinflussung.** (4 200 Wörter & Abb.)

1931 621 .43
Elektrotechnische Zeitschrift, 44. Heft, 29. Oktober, S. 1362.
Ein **benzinelektrischer Eisenbahnwagen.** (700 Wörter & Abb.)

1931 621 .33 (.47)
Elektrotechnische Zeitschrift, 44. Heft, 29. Oktober, S. 1364.
Der Stand der Elektrisierung bei den russischen Eisenbahnen. (1 500 Wörter.)

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1931 621 .43
Glasers Annalen, Heft 8, 15. Oktober, S. 69.
LAUDAHN (W.). — **Schnellaufende Dieselmotoren.** (4 900 Wörter & Abb.)

1931 62. (01
Glasers Annalen, Heft 9, 1. November, S. 77.
KREISSIG (E.). — **Materialverfestigung** durch Vorspannung. (2 500 Wörter & Abb.) (Schluss folgt.)

Organ für die Fortschritte des Eisenbahnwesens. (Berlin.)

1931 385 .114 & 656 .222.1
Organ für die Fortschritte des Eisenbahnwesens, Heft 21, 1. November, S. 431.
EHRENSBERGER. — Die **Kosten einer Zugfahrt** in Abhängigkeit von der Fahrweise und der Anstrengung des Triebfahrzeugs. (8 700 Wörter & Abb.) (Schluss folgt.)

1931 621 .9 & 621 .138.5
Organ für die Fortschritte des Eisenbahnwesens, Heft 21, 1. November, S. 444.
SCHMIDT (D.). — Neue **Vorrichtungen für Kesselschmieden.** (1 900 Wörter & Abb.)

1931 625 .213 (.43)
Organ für die Fortschritte des Eisenbahnwesens, Heft 21, 1. November, S. 447.
Neuzeitliches Härten der **Blattfedern der Fahrzeuge.** (1 400 Wörter & Abb.)

Verkehrstechnische Woche. (Berlin.)

1931 656 .223.1
Verkehrstechnische Woche, Nr. 39, S. 521.
ACHTELIK. — Verwendung und betriebliche Ausnutzung der **Personenwagen.** (3 Seiten.)

1931 721 (.43)
Verkehrstechnische Woche, Nr. 40, S. 533.
ROETTCHER. — Der **Reichsbahnarchitekt** und seine heutigen Aufgaben. (4 1/2 Seiten & Abb.)

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1931 62. (01
Zeitsch. des Ver. deutsch. Ing., Nr. 43, 24. Oktober, S. 1328.
THUM (A.). — Zur Steigerung der **Dauerfestigkeit gekerbter Konstruktionen.** (2 400 Wörter & Abb.)

1931 621 .392
Zeitsch. des Ver. deutsch. Ing., Nr. 44, 31. Oktober, S. 1361.
SANDELOWSKY (S.). — Das **Arcatom-Schweissverfahren.** Lichtbogen. Schutzgasschweissung in dissoziiertem Wasserstoffgas nach Langmuir. (1 800 Wörter, 1 Tafel & Abb.)

1931 656 .211 & 656 .212
Zeitsch. des Ver. deutsch. Ing., Nr. 45, 7. November, S. 1395.
Die neuere Entwicklungsrichtung in der **Anlage von Personen- und Güterbahnhöfen.** (2 800 Wörter & Abb.)

1931 62. (01 & 691
Zeitsch. des Ver. deutsch. Ing., Nr. 46, 14. November, S. 1401.
LEHR (E.). — **Stoffprüfung.** (9600 Wörter & Abb.)

1931 624 .7
Zeitsch. des Ver. deutsch. Ing., Nr. 46, 14. November, S. 1415.
HERBST (F.). — Über **Strassenbrücken** mit Vollwand-Stahlüberbau. Eine städtebauliche Studie. (3 000 Wörter & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1931 385 .15 (.4)
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 39, S. 1037.
SAUTER. — Die autonomen Staatsbahnen in Europa. (10 1/2 Seiten.)

1931 656 (.254)
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 39, S. 1048.
WACHSMUTH BAESELER. — Die Frage der Übertragung bei der **Zugbeeinflussung.** (1 1/2 Seite.)

1931 656 .223.2 (.43)
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 40, S. 1065.
SCHROEDER. — Die Verwendung von Grossgüterwagen im Verkehr der Reichsbahn. (3 Seiten.)

1931 656 .254
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 40, S. 1068.
AUST. — Die Frage der Übertragung bei der **Zugbeeinflussung.** (2 Seiten.)

In English.

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(Electrical Section.)

1931 385. (061.4 (.73). 621 .33 (.73) & 621 .39 (.73)
Bull., Amer. Railway Eng. Ass[on], August, p. 1.
Reports on power supply for railway electrification : Electrolysis; Clearances for third rail and overhead working conductors; Protection of tracks used in the loading or unloading of inflammable liquids from danger of fire caused by electric sparks; Specifications for track and third-rail bonds; Illumination-Floodlighting of railroad yards; Design of indoor and outdoor substations; Application of corrosion-resisting material; Form of power contract for large blocks of power; Railway electrifications; Protection of communication facilities; etc. (30 000 words, tables & fig.)

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1931 621 .33 (06 (.73)
Electric Railway Journal, October, p. 559.
American Electric Railway Association Annual Convention report number. (90 000 words.)

1931 621 .31 (.71)
Electric Railway Journal, November, p. 642.
DE ANGELIS (M. L.). — Montreal Tramways extends use of mercury rectifiers. (1 100 words & fig.)

Engineer. (London.)

1931 721 .2
Engineer, No. 3956, November 6, p. 482.
Retaining walls of concrete crib work. (2 400 words & fig.)

1931 385. (01 (.6)
Engineer, No. 3956, November 6, p. 484.
The Trans-Saharan Railway. (1 800 words & fig.)

1931 064 (.42)
Engineer, No. 3956, November 6, p. 486; No. 3957, November 13, p. 522.
The Commercial Motor Transport Exhibition at Olympia (London). (8 500 words & fig.) (To be continued.)

1931 621 .132.8
Engineer, No. 3956, November 6, p. 497.
Geared articulated locomotives. (800 words & fig.)

Engineering. (London.)

1931 721 .3
Engineering, No. 3432, October 23, p. 515.
Reinforced concrete columns. (2 700 words & fig.)

1931 536
Engineering, No. 3432, October 23, p. 518; No. 3433, October 30, p. 550.
JAKOB (M.). — Steam research in Europe and in America. (5 000 words & fig.)

1931 625 .4 (.73)
Engineering, No. 3434, November 6, p. 572.
SKINNER (F. W.). — New York electric subway construction methods. VI. (1 200 words & fig.)

1931 62. (06 (.42) & 625 .142.2 (.42)
Engineering, No. 3435, November 13, p. 616.
The centenary meeting of the British Association. (1 700 words.)

1931 621 .331
Engineering, No. 3435, November 13, p. 622.
Portable mercury-arc rectifier substations. (900 words & fig.)

Engineering News-Record. (New York.)

1931 624 .51 (.73)
Engineering News-Record, No. 17, October 22, p. 640.
Bridging the Hudson at Fort Lee. (5 300 words & fig.)

1931 624 .51 (.73)
Engineering News-Record, No. 17, October 22, p. 646.
HALTEMAN (A. S.). — Erecting towers and floor steel on the Hudson River Bridge. (5 300 words & fig.)

1931 624 .51 (.73)
Engineering News-Record, No. 17, October 22, p. 654.
Ingenious form system speeds up **paving** of Hudson River **bridge floor.** (2 200 words & fig.)

1931 624 .51 (.73)
Engineering News-Record, No. 17, October 22, p. 657.
Complex **approaches** developed to promote efficient use of Hudson River **bridge.** (5 300 words & fig.)

1931 624 .1 (.73)
Engineering News-Record, No. 17, October 22, p. 665.
Well points **drain** swamp under **bridge approach structure.** (800 words & fig.)

1931 624. (0
Engineering News-Record, No. 18, October 29, p. 686.
WEISKOPF (W. H.) & PICKWORTH (J. W.). — **T-flange girders** for heavy service. (900 words, tables & fig.)

1931 624 .81 (.73)
Engineering News-Record, No. 19, November 5, p. 718.
Rare **old bridges** replaced in Boston & Maine. Railroad **terminal improvements** at Boston. (2 500 words & fig.)

1931 69 (06 (.73)
Engineering News-Record, No. 19, November 5, p. 737.
Structural Steel Men consider quota plan. (2 600 words.)

Great Western Railway Magazine. (London.)

1931 656 .215 (.42)
Great Western Railway Magazine, November, p. 463.
Modern **illumination** on the Great Western Railway. (1 800 words & fig.)

Indian Railway Gazette. (Calcutta.)

1931 385 .4 (.498)
Indian Railway Gazette, July, p. 9.
STRAUSS (F.). — **Re-organization of Rumanian State Railways.** Financial and administrative policy. (3 100 words.)

1931 625 .216 (.4)
Indian Railway Gazette, August, p. 40.
STRAUSS (F.). — The problem of the **automatic « coupling »** in Europe. (1 800 words.)

1931 385. (.4)
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STRAUSS (F.). — **Railway administration** in **Central Europe.** (2 900 words.)

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1931 721 .1
Journal, Institution of Engineers, Australia, September, p. 305.
ISAACS (D. V.). — **Reinforced concrete pile formulæ.** (13 000 words, 5 tables & fig.)

1931 656 .212.6
Journal, Institution of Engineers, Australia, September, p. 325.
BICKFORD (Ch. R.). — The **handling of bagged wheat** at Glebe Island, N. S. W. (4 300 words & fig.)

Journal of the Institute of Transport. (London.)

1931 388
Journal of the Institute of Transport, November, p. 8.
The growth of cities. — Inaugural address by Frank Pick, president. (11 500 words.)

1931 656 .1 & 656 .2
Journal of the Institute of Transport, November, p. 22.
PAYNE (H. W.). — Some present limitations in **the transport of freight traffic by railway,** with suggestions. (7 300 words.)

Mechanical Engineering. (New York.)

1931 625 .13 (.73) & 625 .4 (.73)
Mechanical Engineering, November, p. 791.
New York City's Eighth Avenue **subway.** (4 700 words & fig.)

1931 614.8 & 62. (01
Mechanical Engineering, November, p. 805.
HULL (E. H.). — Influence of damping in the elastic mounting of **vibrating machines.** (2 800 words & fig.)

1931 614 .8
Mechanical Engineering, November, p. 814.
MOULTON (R. S.). — **Fire protection** in industry. (2 200 words & fig.)

1931 621 .4
Mechanical Engineering, November, p. 825.
The liquid engine. (2 400 words & fig.)

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1931 385 .1 (.931)
Modern Transport, No. 658, October 24, p. 5.
Railway extensions in New Zealand. (1 700 words.)

1931 656 .213 & 656 .23
Modern Transport, No. 658, October 24, p. 6.
Industrial traffic management. Rebates from dock charges. (900 words.)

1931 385. (091 (.91)
Modern Transport, No. 658, October 24, p. 10.
Transport developments in Malaya. Opening of 327-mile branch line. (1 200 words & fig.)

1931 656 .211.7
Modern Transport, No. 659, October 31, p. 5.
McLAREN BROWN (Sir George). — **Shipping in relation to railways.** Developments on the Canadian Pacific Ry. (1 700 words & portrait.)

1931 656 .1 (.43)
Iodern Transport, No. 659, October 31, p. 6.
Industrial traffic management. Insurance of goods by ail. (900 words & 1 table.)

1931 656 .1 (.43)
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German Railways and road competition. New law ixes universal tariffs. (1 400 words & fig.)

1931 385 .3 (.42)
Iodern Transport, No. 659, October 31, p. 8.
The Board of Trade and the railways. (1 500 words.)

1931 656 .1
Iodern Transport, No. 659, October 31, p. XI, Motor Transport Exhibition Section.
HICKS (Sir Maxwell). — Long-distance transport y road. (3 400 words & fig.)

1931 656 (.71)
Iodern Transport, No. 660, November 7, p. 3.
FERGUSON (G.). — Transport facilities in Canaa. (2 500 words & portrait.)

1931 385. (06 (.54)
Iodern Transport, No. 660, November 7, p. 4.
BURN (D. S.). — The railway position in India. nproving facilities but diminishing traffic. (1 400 ords & portrait.)

1931 656 .253 (.42)
odern Transport, No. 660, November 7, p. 8.
Electro-mechanical colour lights on London & North astern Ry. (350 words & fig.)

1931 656 .1 & 656 .225
odern Transport, No. 660, November 7, p. 9.
PICK (F.). — Present-day railway problems. Handng the small consignment. (1 600 words.)

1931 625 .245 & 656 .225
odern Transport, No. 660, November 7, p. 11.
Railway container competition. Review of results. 000 words.)

1931 656 .23
odern Transport, No. 660, November 7, p. 11.
Industrial traffic management. Lien for rail charges. 100 words.)

1931 656 .1 (.42)
odern Transport, No. 660, November 7, p. III, Motor Transport Exhibition Section.
GOSSELIN (C. le M.). — Road transport and the tional crisis. An appeal for fair play. (1 500 words portrait.)

1931 656 .1 (.42) & 656 .261 (.42)
odern Transport, No. 660, November 7, p. IV, Motor Transport Exhibition Section.
MILNE (J.). — The railways and road transport. view of three years progress. (1 500 words, 1 table fig.)

1931 621 .133.1
Modern Transport, No. 660, November 7, p. VI, Motor Transport Exhibition Section.
Liquid fuel from coal. (1 700 words.)

1931 621 .43
Modern Transport, No. 660, November 7, p. IX, Motor Transport Exhibition Section.
REEVE (C. W.). — The heavy-oil engine in road transport. (1 400 words & portrait.)

1931 621 .43 & 656 .261
Modern Transport, No. 660, November 7, p. X, Motor Transport Exhibition Section.
SHEARMAN (J.). — Motor vehicle design and equipment. (3 800 words & fig.)

1931 385 .15 (.942)
Modern Transport, No. 661, November 14, p. 4.
The Railways of South Australia. Evils of State ownership. (1 700 words.)

1931 621 .33 (.494)
Modern Transport, No. 661, November 14, p. 5.
Railway electrification in Switzerland. The new seven years' programme. (1 000 words & fig.)

1931 385 .22 & 656 .23
Modern Transport, No. 661, November 14, p. 6.
Industrial traffic management. Rebates on traffic shipped coastwise. (1 100 words.)

1931 656 .1 (.54)
Modern Transport, No. 661, November 14, p. 8.
STONE (T. A. F.). — Indian railways and road competition. Attracting short haul traffic. (1 400 words & 1 table.)

1931 621 .43, 656 .1 & 656 .261
Modern Transport, No. 661, November 14, p. 14.
Railway requirements in road transport. (2 700 words.)

1931 064 (.42)
Modern Transport, No. 661, November 14, p. 17.
TWELVETREES (R.). — Technical aspect of the Motor Transport Exhibition. (10 000 words & fig.)

1931 656 .1 (.41)
Modern Transport, No. 661, November 14, p. 27.
London Midland & Scottish (Northern Counties Committee) bus development in Ireland. (1 700 words & fig.)

1931 347 .763 (.42) & 656 .1 (.42)
Modern Transport, No. 661, November 14, p. 28.
BRISTOW (F. G.). — The Road traffic Act, 1930. Its adverse effects upon the road motor transport industry. (4 800 words & fig.)

Proceedings, American Society of Civil Engineers. (New York.)

1931 55
Proc., Amer. Soc. Civil Eng., October, p. 1165.
GILBOY (G.). — **Soil mechanics research.** (10 000 words & fig.

Railway Age. (New York.)

1931 625 .172 & 625 .174
Railway Age, No. 15, October 10, p. 542.
Fighting snow — Killing weeds. (3 300 words & fig.)

1931 621 .139 & 656 .212.6
Railway Age, No. 15, October 10, p. 546.
Ship 80 per cent by container on Big Four. (2 000 words & fig.)

1931 385 .4 (.73)
Railway Age, No. 15, October 10, p. 549.
Four-system plan submitted to Interstate Commerce Commission. (4 600 words.)

1931 313 : 656
Railway Age, No. 15, October 10, p. 553.
Statistics pay their way. (2 200 words & fig.)

1931 656 .1 & 656 .225
Railway Age, No. 15, October 10, p. 558.
TALBOT (R. W.). — **Freight car vs. motor truck.** (2 000 words & 1 table.)

1931 651
Railway Age, No. 15, October 10, p. 582.
Use of modern machinery reduces accounting expense. (2 600 words & fig.)

1931 621 .139 & 656 .212.6
Railway Age, No. 16, October 17, p. 585.
SORENSEN (A. L.). — **Erie goes to containers for supply work.** (2 200 words & fig.)

1931 625 .231 (.73)
Railway Age, No. 16, October 17, p. 588.
Ice used for air cooling in Boston & Maine coach. (2 000 words, 2 tables & fig.)

1931 621 .13, 621 .335 & 621 .43
Railway Age, No. 16, October 17, p. 593.
WALKER (E. B.). — **Steam, electric, and internal combustion locomotives.** (2 400 words & fig.)

1931 624. (0
Railway Age, No. 16, October 17, p. 598.
Some ingenious bridge floor details. (1 100 words & fig.)

1931 621 .43
Railway Age, No. 17, October 24, p. 620.
Oil-electrics are effecting savings in switching service. (2 700 words, tables & fig.)

1931 656 .213
Railway Age, No. 17, October 24, p. 629.
Modern rail-to-keel terminal built at New York Harbor. (3 800 words & fig.)

1931 385 .3 (.73) & 656 .23 (.73)
Railway Age, No. 17, October 24, p. 634.
LANE (H. F.). — **Rate rise application denied.** (8 200 words.)

1931 656 .1
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TALBOT (R. W.). — **Co-ordinated rail and truck service.** (3 400 words.)

1931 623 .144.4
Railway Age, No. 18, October 31, p. 661.
Save money in handling material. (3 100 words & fig.)

1931 659
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Passenger Men favor national advertising program. (2 500 words.)

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Three air-conditioned trains operated by the Baltimore & Ohio. (900 words & fig.)

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A new **aluminium alloy** for casting. (600 words.)

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TWINBERROW (J. D.). — The water space **stays of locomotive fireboxes.** (2 400 words & fig.)

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New **saloon** for H. E. the Governor-General of South Africa. (400 words & fig.)

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Water softening on the London Midland & Scottish Railway. (600 words.)

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RIBERA (J. E.). — El puente de Plougastel sobre el Elorn. (2 500 palabras & fig.)

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De roldeuren en de draaibrug van de nieuwe Noordsluis te Bremerhaven. (3 600 woorden & fig.)

1931 621 .138.5 (.492) & 625 .26 (.492)
De Ingenieur, nr 45, 6 November, p. 115.

HUPKES (W.). — Werkplaatsbeheer bij de Nederlandsche Spoorwegen. (6 000 woorden, 3 tafereelen & fig.)

1931 621 .33 (.492)
De Ingenieur, nr 45, 6 November, p. 130.

VERSCHOOR (H. E.). — Elektrificatie en dienstregeling bij de Nederlandsche Spoorwegen. (800 woorden.)

Spoor- en Tramwegen. (Utrecht.)

1931 625 .13 (.92)
Spoor- en Tramwegen, nr 9, 27 October, p. 223.

ELLERBROECK (M.). — Tunnelbouw in Zuid-Sumatra. (1 800 woorden & fig.)

1931 621 .33 (.492)

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VAN LESSEN (H. J.). — **De electrificatie** van de jnen Amsterdam-Alkmaar en Velsen-Uitgeest. (3 500 oorden, 3 tafereelen & fig.)

1931 625 .232

poor- en Tramwegen, nr 9, 27 October, p. 233.

VAN DER BURG (J. E.). — **De elektrische inrichngen** der postrijtuigen No's 7011-7021. (1 500 woorden fig.)

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poor- en Tramwegen, nr 9, 27 October, p. 240.

HUIZER (S. L.). — **Viaduct** over den Muiderstraateg. (1 500 woorden & fig.)

1931 621 .43 (.45)

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Ansaldo-Diesel-Locomotief met directe aandrijving oor de Italiaansche Spoorwegen. (1 200 woorden.)

In Czech.
(= 91.886)

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1931 385 .524 (.437) = 91 .886
& 656 (.437) = 91 .886

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Zelezniční Revue. (Prague.)

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1931 656 .25 = 91 .886

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SVOBODA. — **Signalling questions. Locomotive cab signals. Automatic train control.** (6 000 words.) (To be continued.)

Zpravy zeleznicnich inženýrů. (Prague.)

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Zprávy zeleznicnich inzenyru, No. 10, p. 197.

VAVERKA. — **Rail creep** on curves. (2 000 words.) (Concluded.)

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SLABYHOUD. — **The weighing of locomotives** (1 000 words.) (Continued.)

In Polish.
(= 91.885.)

Inżynier Kolejowy. (Warszawa.)

1931 621 .132.6 (.497.2) = 91 .885

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BRYLING (G.). — **2-12-4 tank locomotive** of the Bulgarian Railways. (2 700 words & fig.)

1931 624 .32 (.438) = 91 .885

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SUSZYNSKI (S.). — **Construction of a bridge** on the diametral line at Warsaw. (2 100 words & fig.)

1931 385 .52 (.438) = 91 .885

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DALEWSKI (E.). — Proposed new method for the **calculation of working times and wages** in the Permanent Way Department. (3 000 words & fig.)

In Serbian.
(= 91.882)

Saobračajni pregled. (Belgrad.)

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MARKOVIC. — The Grebenarovic **automatic coupling.** (4 000 words & fig.)

1931 621 .13 (.497.1) = 91 .882

Saobracajni pregled, No. 10, p. 422.

NIKOLIC & GREBENAROVIC. — The new **4-6-2 express locomotives** of the Yougoslav State Railways and the former 2-6-2 type locomotives. (7 000 words & diagr.)

1930 625 .225 = 91 .882

Saobracajni pregled, No. 10, p. 430.

BERTIC. — **The earning power of light and heavy goods trains.** (4 000 words.)

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GREBENAROVIC. — The Krajelvo **repair shop** for **standard gauge rolling stock.** (8 500 words.) (Concluded.)

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[016 .385. (02]

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AMBERT (A.), professeur.

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BARBEROT (E.).

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Paris et Liége, Librairie polytechnique Ch. Béranger. Un volume, 1 086 pages et 943 figures. (Prix : 130 francs français.)

1931 33. (02

COLSON (C.), membre de l'Institut, inspecteur général des ponts et chaussées, vice-président honoraire du Conseil d'Etat de France, membre du Conseil supérieur des chemins de fer de France.

Cours d'économie politique professé à l'Ecole Polytechnique et à l'Ecole des Ponts et Chaussées.

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1931 621. (06

Congrès international de mécanique générale, Liége, 31 août-5 septembre 1930.

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La collection complète : 280 francs français.

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La pratique des traitements thermiques.

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L'objet et l'étendue de la preuve incombant, en droit italien, au lésé, en matière de transport de voyageurs. (1 600 mots.)

1931 313 .385 (.485)

Bull. des transp. intern. par ch. de fer, novembre, p. 579.

Les chemins de fer suédois en 1928. (1 600 mots.)

Bulletin technique de la Suisse romande. (Vevey.)

1931 625 .253

Bull. techn. de la Suisse romande, n° 25, 12 décembre, p. 313.

Un nouveau frein à air comprimé, inépuisable et à desserrage modérable à volonté. (1 800 mots & fig.)

Chronique des transports. (Paris.)

1931 656 .2

Chronique des transports, n° 23, 10 décembre, p. 7.

La réforme des conditions d'exploitation des chemins de fer. (1 800 mots.)

Ferrovia. (Bruxelles.)

1931 385

Ferrovia, novembre, p. 4.

La crise mondiale et son influence sur les transports par chemin de fer. (1 400 mots & diagr.)

1931 621 .43 (.493)

Ferrovia, novembre, p. 6.

Les voitures automotrices en service sur le réseau de la Société nationale des chemins de fer belges. (2 100 mots & fig.)

Génie civil. (Paris.)

1931 627 (.44)

Génie Civil, n° 2571, 21 novembre, p. 517.

PAWLOWSKI (A.). — L'état actuel du port du Havre et les projets d'extension dans l'estuaire de la Seine. (5 600 mots & fig.)

1931 621 .81

Génie Civil, n° 2571, 21 novembre, p. 525.

Appareil de transmission à variation de vitesse automatique, système Diskon. (1 500 mots & fig.)

1931 656 .1 (.44)

Génie Civil, n° 2571, 21 novembre, p. 526.

Comparaison des dépenses budgétaires relatives au réseau routier français et des recettes procurées à l'Etat par la circulation automobile. (2 500 mots & fig.)

1931 621. (01 & 721 .9

Génie Civil, n° 2572, 28 novembre, p. 547.

CAMINADE (H.). — Le règlement de la Chambre syndicale française sur les constructions en béton armé et les prescriptions officielles étrangères. (6 900 mots & fig.)

1931 625 .14

Génie Civil, n° 2573, 5 décembre, p. 574.

FERREIRA (V.). — Voies ferrées pour automotrices montées sur pneumatiques. (2 300 mots & fig.)

1931 624 .32 (.73)

Génie Civil, n° 2574, 12 décembre, p. 593.

CAUFOURIER (P.). — Le pont en arc de 510 mètres, sur le Kill Van Kull, près de New-York. (4 000 mots & fig.)

1931 621 .116

Génie Civil, n° 2574, 12 décembre, p. 607.

La fabrication des collecteurs ondulés pour les chaudières à vapeur. (700 mots & fig.)

La Science et la Vie. (Paris.)

1931 621 .87 (.42)

La science et la vie, décembre, p. 472.

MARCHAND (J.). — Voici le plus puissant appareil de levage sur les chemins de fer. (2 000 mots & fig.)

1931 625 .245 (.42)

La science et la vie, décembre, p. 523.

Un wagon spécial pour le transport des locomotives. (600 mots & fig.)

La Traction électrique. (Paris.)

1931 621 .335

La Traction Electrique, juillet, p.168.

MEYFARTH (G. L.). — Tendances modernes pour la construction des locomotives et des automotrices à bogies. (1 400 mots & fig.)

1931 621 .337

La Traction Electrique, juillet, p. 172.

HUG (A. M.). — La commande individuelle des essieux; des systèmes utilisés pour locomotives et motrices dans l'exploitation des voies ferrées de toute nature. (5 000 mots & fig.) (A suivre.)

Les Chemins de fer et les Tramways. (Paris.)

1931 625 .242 & 625 .245

Les chemins de fer et les tramways, novembre, p. 211.

Wagon-tombereau à déchargement automatique de 60 tonnes de chargement. (1 800 mots & fig.)

1931 621 .135.4 & 625 .215

Les chemins de fer et les tramways, novembre, p. 213.

Amélioration de l'inscription en courbe par l'orientation automatique des essieux. (2 700 mots & fig.)

1931 621 .332 (.45)
Les chemins de fer et les tramways, novembre, p. 216.
Sous-stations mobiles de redresseurs à vapeur de mercure pour les Chemins de fer de l'Etat italien. (4 500 mots & fig.)

1931 625 .245 & 656 .225
Les chemins de fer et les tramways, novembre, p. 221.
Perfectionnements apportés aux « Containers ». (3 600 mots & fig.)

1931 625 .214
Les chemins de fer et les tramways, novembre, p. 224.
BRILLIÉ (H.). — **Contribution à l'étude du graissage des fusées d'essieux des matériels roulants.** (Congrès du Génie Civil, 23-29 septembre 1931). (5 400 mots & fig.)

1931 656 .253
Les chemins de fer et les tramways, novembre, p. 228.
Dispositif de commande automatique des pétards des signaux d'arrêt des voies sur lesquelles les trains circulent dans les deux sens. (3 200 mots & fig.)

1931 625 .173
Les chemins de fer et les tramways, novembre, p. 230.
Groupe moteur dégarnisseur pour l'entretien des voies ferrées. (800 mots & fig.)

1931 621 .332
Les chemins de fer et les tramways, novembre, p. 231.
Support de rail conducteur. (900 mots & fig.)

1931 625 .144.4
Les chemins de fer et les tramways, novembre, p. 232.
Arrache-crampons. (4 500 mots & fig.)

1931 621 .133.2
Les chemins de fer et les tramways, novembre, p. 235.
Dispositif d'amenée d'air supérieur pour foyers de locomotives. (700 mots & fig.)

L'Industrie des voies ferrées et des transports automobiles. (Paris.)

1931 656 .1 & 656 .2
L'Ind. des voies ferrées et des transp. autom., octobre, p. 296.
BARTHELEMY (E.). — **Transport par route des wagons de chemins de fer par remorques automobiles porte-wagons.** (2 200 mots & fig.)

1931 621 .333
L'Ind. des voies ferrées et des transp. autom., octobre, p. 62.
VENTE. — **Equipements à moteurs compound sur voitures à un agent.** Rapport présenté à la VI^e assemblée générale technique (Lille, 15-18 juin 1931). (16 000 mots & fig.)

1931 625 .62 (.44)
L'Ind. des voies ferrées et des transp. autom., novembre, p. 319.
Les nouvelles voitures des tramways strasbourgeois. (2 400 mots & fig.)

1931 625 .611
L'Ind. des voies ferrées et des transp. autom., novembre, p. 114.
CAHEN. — **Incidence sur les résultats d'exploitation des voies ferrées d'intérêt local et des tramways, des modifications intervenues depuis 1914 dans les dispositions législatives et dans la situation économique.** Rapport présenté à la VI[e] assemblée générale technique (Lille, 15-18 juin 1931), avec discussion. (23 000 mots.) (A suivre.)

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1931 621 .133.3 & 621 .134.3
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GÉRARD (P.). — **La chaudière Lœffler à haute pression.** (4 000 mots & fig.)

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1931 625 .232 (.44)
Revue générale des chemins de fer, décembre, p. 385.
PLA (P.). — **Les nouvelles voitures métalliques pour grandes lignes étudiées par l'Office central d'études de matériel de chemins de fer.** (8 800 mots & fig.)

1931 385 .113 (.44)
Revue générale des chemins de fer, décembre, p. 404.
Résultats d'exploitation des Chemins de fer d'Alsace et de Lorraine en 1930. (4 200 mots.)

1931 625 .11 (.43)
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Les nouvelles lignes projetées par la Reichsbahn dans les régions frontières. (700 mots & carte.)

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AMPHOUX (M.). — **Le chemin de fer Congo-Océan.** (4 800 mots.)

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1931 669. (06
Revue universelle des mines, n° 11, 1[er] décembre, p. 358.
MARÉCHAL (J.R.). — **Monographie sur la métallurgie à l'exposition internationale de Liége en 1930.** (23 500 mots & fig.) (A suivre.)

1931 669 .1
Revue universelle des mines, n° 11, 1[er] décembre, p. 391.
CHEVENARD (P.) & PORTEVIN (A.). — **Contribution à l'étude du revenu des aciers trempés.** (3 000 mots & fig.) (A suivre.)

In German.

Die Lokomotive. (Wien.)

1931 **621 .13 (09 (.436)**
Die Lokomotive, November, S. 209.
Die **ursprünglichen Lokomotiven** der Eisenbahn Graz-Köflach. (5 700 Wörter & Abb.)

1931 **621 .33 (.45)**
Die Lokomotive, November, S. 217.
Die **Elektrifikation von Haupt- und Nebenbahnen** in Italien mit hochgespanntem Gleichstrom. (3 700 Wörter & Abb.)

Die Reichsbahn. (Berlin.)

1931 **656 .1 (.43)**
Die Reichsbahn, Nr. 41, S. 928.
Verordnung über den **Überlandverkehr mit Kraftfahrzeugen** vom 6. Oktober 1931 in **Deutschland.** (4 Seiten.)

1931 **656 .1 (.43)**
Die Reichsbahn, Nr. 41, S. 932.
Das **neue Kraftverkehrsrecht.** (2 1/2 Seiten.)

1931 **624 .2, 625 .14 (01 & 625 .212**
Die Reichsbahn, Nr. 41, S. 935.
KOMMERELL. — Der Zusammenhang zwischen dem **Achsdruck und Metergewicht der Wagen** und der **Tragfähigkeit des Oberbaus und der Brücken.** (2 Seiten.)

1931 **385 .1 (.43)**
Die Reichsbahn, Nr. 42, S. 946.
PRANG. — Die **Finanzlage** der Reichsbahn. (5 Seiten.)

1931 **656 .225**
Die Reichsbahn, Nr. 42, S. 951.
REFFLER. — Massnahmen zur **Beschleunigung der Stückgüterzüge und Verbesserung der Stückgüterbeförderung.** (6 1/2 Seiten & Abb.)

1931 **656 .222.5**
Die Reichsbahn, Nr. 43, S. 976.
SAAGER. — **Personenverkehrswerbung** im Nahverkehr. (2 Seiten & Abb.)

1931 **658 .15 (.43)**
Die Reichsbahn, Nr. 45, S. 1020.
Die **Neuinvestitionen im Verkehrswesen.** (8 1/2 Seiten & Diagr.)

1931 **656 .254**
Die Reichsbahn, Nr. 46, S. 1037.
Vorläufige Richtlinien für die **Aufstellung und Unterhaltung von Warnkreuzen** an Wegübergängen in Schienenhöhe.
A. Warnkreuze bei zwei nahe aufeinander folgenden Wegübergängen in Schienenhöhe.
B. Warnkreuze bei recht- oder schiefwinklig von einem Seitenweg abzweigendem Wegübergang in Schienenhöhe.
C. Warnkreuze bei Wegübergängen in Schienenhöhe an Bahnen, deren Bahnkörper zum Wege gehört oder unmittelbar neben dem Wege liegt. (3 1/2 Seiten & Abb.)

Elektrische Bahnen. (Berlin.)

1931 **621 .333**
Elektrische Bahnen, November, S. 313.
KERN (E.). — Der **kommutatorlose Einphasen-Lokomotivmotor** für 40 bis 60 Hertz. (5 300 Wörter & Abb.)

1931 **621 .332**
Elektrische Bahnen, November, S. 322.
GRANER (H.). — Der **Zusammenschluss des Wechselstrombahnnetzes** von 16 2/3 Hertz mit dem Drehstromnetz von 50 Hertz. (4 800 Wörter & Abb.) (Schluss folgt.)

1931 **621 .333**
Elektrische Bahnen, November, S. 328.
MUNDT (R.). — Die Bestimmung der Wälzlager für Bahnmotoren. (3 800 Wörter & Abb.)

Elektrotechnische Zeitschrift. (Berlin.)

1931 **625 .143.3**
Elektrotechnische Zeitschrift, 19. November, Heft 47, S. 1449.
Beitrag zur **Bestimmung des inneren Scheinwiderstandes einer Eisenbahnschiene.** (700 Wörter.)

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1931 **62. (01**
Glasers Annalen, 15. November, Heft 10, S. 85.
KREISSIG (E.). — **Materialverfestigung durch Vorspannung.** (2 000 Wörter & Abb.)

1931 **621 .134.1**
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MENZEL (O.). — Ein Beitrag zur **Berechnung der Stangenschäfte** von Treib- und Kuppelstangen für Lokomotiven als Stäbe gleicher Beanspruchung. (1 300 Wörter & Abb.)

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1931 **656 .232**
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EHRENSBERGER. — Die **Kosten einer Zugfahrt** in Abhängigkeit von der Fahrweise und der Anstrengung des Triebfahrzeugs. (6 600 Wörter, 7 Tafeln und Abb.)

1931 621 .131 .1
Organ für die Fortschritte des Eisenbahnwesens, 15. November, Heft 22, S. 460.
WETZLER (W.). — **Leistungs- und Verbrauchstafeln für Triebfahrzeuge.** (5 600 Wörter & Abb.)

1931 621 .138.3
Organ für die Fortschritte des Eisenbahnwesens, 15. November, Heft 22, S. 469.
Reinigung von Lokomotiven durch Abspritzen. (500 Wörter & Abb.)

1931 625 .212 & 625 .143.1
Organ für die Fortschritte des Eisenbahnwesens, 1. Dezember, Heft 23, S. 471.
HEUMANN. — **Spurkranz und Schienenkopf.** (7 000 Wörter & Abb.) (Schluss folgt.)

1931 621 .131 .1
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ACHTERBERG (Th.). — Der **Dampfverbrauch** von **Lokomotiven** bei der günstigsten Geschwindigkeit. (1 400 Wörter & Abb.)

1931 625 .235 & 625 .236
Organ für die Fortschritte des Eisenbahnwesens, 1. Dezember, Heft 23, S. 484.
LAUTENSCHLAGER (H.). — **Personenwagen-, Reinigungs- und Lackpflegeanlage.** (900 Wörter & Abb.)

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ROETTCHER. — Der **Eisenbahnarchitekt** und seine **heutigen Aufgaben.** (3 1/2 Seiten & Abb.) (Schluss.)

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EGGERT. — **Dringliche Wagenladungen** auf den **Rangierbahnhöfen.** (4 Seiten).

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FISCHER. — Kritische **Streckenbelastung von Nebenbahnen.** (2 1/2 Seiten & Diagr.)

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GRENZEBACH. — **Luftschutz** (Flugzeug-Schutz) **bei der Eisenbahn.** (7 1/2 Seiten & Abb.)

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1931 62. (01
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LEHR (E.). — Wege zu einer wirklichkeitsgetreuen **Festigkeitsrechnung.** (6 900 Wörter & Abb.)

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TAFEL (W.) und VIEHWEGER (E.). — **Einfluss der Verformungsgeschwindigkeit auf dem Formänderungswiderstand.** (4 200 Wörter & Abb.)

1931 621 .116
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PFLEIDERER (E.). — **Betriebserfahrungen an einem 42 at-Grosskessel.** (5 600 Wörter & Abb.)

1931 624 .2
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ZELLER (W.) & KOCH (H. W.). — Kritik der **Aufzeichnung von Schwingungsmessern.** (2 600 Wörter & Abb.)

1931 624 .2
Zeitsch. des Ver. deutsch. Ing., 12. Dezember, Nr. 50, S. 1517.
AMBRONN (R.). — **Aufzeichnen schneller Schwingungen.** (800 Wörter & Abb.)

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1931 656 .1 (.43)
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BECK. — Die neue **Reichsverordnung über den Kraftwagenverkehr.** (9 Seiten.)

1931 625 .143.4
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HENKES. — **Der Schienenstoss als Gelenk.** (3 1/2 Seiten & Abb.)

1931 656 .23 (.438)
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Selbstkosten und Tarife der Polnischen Staatsbahn. — Staatliche Zuschüsse für die seewärtige Ausfuhr. (1 1/2 Seiten.)

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GAIER. — **Maschinelle Hilfsmittel** im Verwaltungs- und Verkehrsdienst. (8 1/2 Seiten.)

1931 625 .144.2. (09
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BÄSELER. — **Auflaufbogengleise,** ihre Geschichte und ihr **heutiger Stand.** (1 Seite.)

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KÜMMELL. — Überall **Ablaufberge.** (6 Seiten & Abb.)

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SHAMBERGER (J. P.) & LANGER (B. F.). — **Rail stresses and locomotive tracking characteristics** found in tests on the Great Northern Railway. (21 000 words, tables & fig.)

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LEGARÉ (B. P.). — **Rebuilding track** under heavy traffic. (2 400 words & fig.)

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COOK (S. S.) & BROCKMAN (C.). — Progress in **railway transformer design.** (1 400 words & fig.)

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Electric Railway Journal, December, p. 695.
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1931 656. (064
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Public Works, Roads and Transport Exhibition. (6 200 words & fig.)

1931 621 .138.3 (.42)
Engineer, No. 3959, November 27, p. 553.
Locomotive **boiler washing plant** at Stratford. (600 words & fig.)

1931 625 .143.5
Engineer, No. 3959, November 27, p. 570.
Unit **steel sleepers.** (200 words & fig.)

1931 62. (01 & 669 .1
Engineer, No. 3960, December 4, p. 599.
Corrosion and the life of structures. (1 400 words.)

1931 621 .132.6 (.82)
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Buenos Aires and Pacific Railway : **three-cylinder tank engines.** (1 200 words & fig.)

1931 621 .392 & 721 .9
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Arc-welded factory building in Canada. (2 000 words & fig.)

1931 621 .31
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Oerlikon **mercury arc rectifiers.** (3 400 words & fig.)

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The **cracking of riveted boiler drums.** (1 900 words & fig.)

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JAKOB (M.). — Steam research in Europe and in merica. (10 800 words, tables & fig.)

1931 656 .253
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The Strowger-Hudd automatic train control system. 1 000 words.)

1931 656 .215 (.42)
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Road and railway lighting at the port of London uthority docks. (800 words & fig.)

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Developments in mercury-arc rectifiers and valves. 2 900 words & fig.)

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HARTMANN (J.). — Mercury-jet commutation. 4 600 words & fig.)

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History and development of the submarine rock drill. 2 200 words & fig.)

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GOLDBERG (J. E.). — Vertical-load analysis of igid building frames made practicable. (1 500 words fig.)

1931 624 .51 (.73)
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BOBLOW (R.). — Stringing rope-strand cables eatures St. Johns bridge construction. (3 300 words fig.)

1931 624 .32 (.73)
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SANDBERG (C. H.). — High-level bridge eliminates ld swing span. (2 200 words & fig.)

1931 624 .32 (.73)
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CRIDER (H. E.) & NEYENESCH (H. G.). — Cantilever erection of truss bridge. (3 300 words & fig.)

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Corrugated-iron pipe of multi-plate design introduced on Illinois Central Railroad. (1 400 words & fig.)

1931 691
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DAVIS (A. F.). — Residence with welded frame of standard structural shapes. (800 words & fig.)

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1931 656 .254 (.42)
Modern Transport, No. 662, November 21, p. 5.
L. N. E. R. traffic control. New selective ringing telephone system at Darlington. (900 words & fig.)

1931 656 .1 (.42)
Modern Transport, No. 662, November 21, p. 11.
Railways and long distance buses. (1 200 words.)

1931 621 .43
Modern Transport, No. 663, November 28, p. 3.
Improved high-speed Diesel locomotives for shunting and industrial purposes. (1 100 words & fig.)

1931 656 .261
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Industrial traffic management. No. 15. — Railhead distribution. (1 100 words.)

1931 656 .23
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Railways and their charges. (1 000 words.)

1931 656 .23
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Railway charging should be simplified. (1 800 words & 1 table.)

1931 385 .13 (.42) & 656 .23 (.42)
Modern Transport, No. 664, December 5, p. 7.
Railway freight rebates. (1 400 words.)

1931 388
Modern Transport, No. 664, December 5, p. 10.
Limited-stop omnibuses and motor coaches. (1 700 words.)

1931 621 .13 (0, 621 .137 & 621 .138
Modern Transport, No. 665, December 12, p. 3.
Locomotive engineering and operating. No. 1. — Suggested improvements in train working. (1 500 words.) (To be continued.)

1931 656 .211 (.82)
Modern Transport, No. 665, December 12, p. 5.
Remodelling of **Plaza Constitucion station.** (4 500 words & fig.)

Proceedings, Institution of Civil Engineers. (London.)

1931 625 .13 (.42)
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McCALLUM (R. T.). — The **opening-out of Cofton tunnel**, London Midland & Scottish Railway. Paper, discussion and correspondence. (16 300 words, 22 tables & fig.)

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FREEMAN (F. R.). — The **strength of arc-welded joints.** Paper, discussion and correspondence. (34 000 words, tables & fig.)

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GIBB (C. D.). — **Post-war land turbine development.** (30 000 words, tables & fig.)

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FARMER (H. O.) & ALCOCK (J. F.). — **Fuel injection systems for high-speed oil-engines.** (13 400 words & fig.)

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COKER (E.). & LEVI (R.). — **The stress distribution in fusion joints.** (7 800 words & fig.)

1931 621 .116
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OAKDEN (J. C.). — The significance of the term « efficiency » as applied to **steam-nozzles.** (1 400 words.)

1931 621 .116
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HODKINSON (B.) & DEVEY (A. E.). — The amount of decrease of **nozzle efficiency** caused by non-uniformity of velocity distribution. (12 000 words & fig.)

1931 621 .131.2, 625 .1 & 625 .2
Proc., Institut. of Mech. Eng., vol. 120, p. 643.
LOMONOSSOFF (G. V.). — **Problems of railway mechanics.** (6 500 words & fig.)

1931 658
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WATSON (F. L.). — — **Obsolescence and organization.** (2 400).)

1931 385. (071 .1
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WOOLLISCROFT (G. W.). — **The training of an engineer.** (3 000 words.)

1931 621 .43
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Railway Age, No. 19, November 7, p. 698.
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TURNEY (J. R.). — **The motor truck** — a threat and an opportunity. (5 900 words.)

1931 624 .32 (.73)
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BISHOP (F. J.). — **Swing draw span during erection.** (1 700 words & fig.)

1931 625 .162 & 656 .254
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Modern **highway crossing protection** reduces operating costs. (2 000 words & fig.)

1931 385. (06 (.73)
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Railway Business Association meeting in Chicago 4th. November 1931. (8 000 words.)

1931 621 .13 (
Railway Age, No. 21, November 21, p. 776.
The modern locomotive — what and why. (3 000 words & fig.)

1931 625 .122 (.73)
Railway Age, No. 21, November 21, p. 783.
New line built into Kansas City. (3 100 words & fig.)

1931 656 .1
Railway Age, No. 22, November 28, p. 812.
Who pays rural highway costs? (1 000 words.)

1931 621 .138.2 (.73)
Railway Age, No. 22, November 28, p. 814.
Modern **coal and cinder plants** will save money. (3 000 words & fig.)

1931 656 .1
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Who pays for highways? (1 000 words, 1 table & fig.)

1931 621 .132.5 (.73)
Railway Age, No. 22, November 28, p. 829.
Santa Fé **locomotive** 5 000 **tested.** (1 200 words, 3 tables & fig.).

1931 656 .1 (.73)
Railway Age, No. 22, November 28, p. 835.
REDDINGTON (J. J.). — Better **station facilities** increase traffic. (1 700 words & fig.)

1931 656 .1 (.73)
Railway Age, No. 22, November 28, p. 837.
Reading proposes new **truck routes.** (1 600 words & fig.)

Railway Engineer. (London.)

1931 621 .13 (0
Railway Engineer, December, p. 446.
The future of the **steam locomotive.** (1 100 words.)

1931 621 .13 (0
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Modern **locomotive performance.** (1 100 words.)

1931 621 .134.1
Railway Engineer, December, p. 447.
Piston-valve leakage. (700 words.)

1931 621 .13 (0
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Locomotive design and equipment. A series of 37 articles by engineers specialising in the design and equipment of locomotives. Together they form a summary of the ideas held by their respective writers on this general subject and although not unnaturally giving expression to conflicting views in many cases, serve as an indication of probable future development of the reciprocating type of steam locomotive. (33 000 words & fig.)

1931 621 .131
Railway Engineer, December, p. 488.
MIALL (S.). — **Factors affecting the thermal efficiency of the steam engine.** (3 000 words & fig.)

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1931 625 .245 (.42)
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Conveyance of milk by rail. New **six-wheeled tank wagons** built at Swindon Works, Great Western Railway. (350 words & fig.)

1931 625 .143.3 (.42)
Railway Gazette, No. 21, November 20, p. 651.
Reducing curve wear by oiling wheel flanges. (600 words & fig.)

1931 625 .245 (.82)
Railway Gazette, No. 21, November 20, p. 653.
Special vehicles for the Buenos Ayres Western Railway. (1 200 words & fig.)

1931 656 .1 (.41)
Railway Gazette, No. 21, November 20, p. 657.
Belfast **bus station and garage.** (900 words & fig.)

1931 656 .1 (.42)
Railway Gazette, No. 21, November 20, p. 661.
Railways and road transport in Argentina. (2 500 words.)

1931 625 .1 (071 (.42)
Railway Gazette, No. 22, November 27, p. 681.
The **training of permanent way men.** (750 words.)

1931 656 .234 (.42)
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SIMPSON (H. L.). — **Reduced fare facilities** on French Railways. (2 200 words.)

1931 621 .335 (.42) & 621 .43 (.42)
Railway Gazette, No. 22, November 27, p. 683.
A **Diesel-electric rail-car** test on the London & North Eastern Railway. (350 words & fig.)

1931 621 .43 (.42)
Railway Gazette, No. 22, November 27, p. 684.
Small Diesel locomotives. (1 700 words & fig.)

1931 656 .253 (.42)
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A substitute for **fog-signalling and automatic train control.** (800 words & fig.)

1931 625 .245 (.42)
Railway Gazette, No. 22, November 27, p. 690.
New **hopper coal wagons and storage vans.** (700 words & fig.)

1931 656 .255 (.943)
Railway Gazette, No. 22, November 27, p. 692.
Special layout for **passing trains at unattended stations on single lines,** Queensland Railways. (900 words & fig.)

1931 621 .132.3 (.73)
Railway Gazette, No. 23, December 4, p. 713.
The « **Hudson** » **type locomotive** in North America. (1500 words & fig.)

1931 625 .245 (.942)
Railway Gazette, No. 23, December 4, p. 716.
Sheep vans for the South Australian Railways. (500 words & fig.)

1931 625 .18 (.42)
Railway Gazette, No. 24, December 11, p. 746.
An up-to-date **railway building** works. (500 words & fig.)

1931 385 .1 (.44)
Railway Gazette, No. 24, December 11, p. 747.
French **railway re-organisation.** (4 000 words & 2 tables.)

1931 621 .43
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Diesel engines. (1 500 words.)

1931 625 .143.3 & 621 .392
Railway Gazette, No. 24, December 11, p. 751.
Railway **crossing maintenance by welding.** (2 900 words & fig.)

Railway Mechanical Engineer. (New York.)

1931 625 .243 (.73)
Railway Mechanical Engineer, November, p. 525.
Delaware & Hudson builds 100 **box cars.** (1 800 words & fig.)

1931 621 .132.5 (.44)
Railway Mechanical Engineer, November, p. 527.
Rebuilt **4-6-2 compound locomotives** show economies. (6 300 words, tables & fig.)

1931 385 .587 & 625 .26
Railway Mechanical Engineer, November, p. 534.
DEMAREST (T. W.). — Make your **car foremen** your assistants. (3 000 words.)

1931 621 .133.7
Railway Mechanical Engineer, November, p. 537.
ALSBERG (J.). — **Scale prevention in closed feed-water heaters.** (1 800 words.)

1931 625 .236 (.71)
Railway Mechanical Engineer, November, p. 544.
A **machine for cleaning carpets.** (1 500 words & fig.)

1931 625 .234 (.73)
Railway Mechanical Engineer, November, p. 556.
York **air-conditioning equipment for passenger cars.** (1 300 words & fig.)

Railway Signaling. (Chicago.)

1931 656 .253 (.73) & 656 .255 (.73)
Railway Signaling, November, p. 365.
Signaling the new Kansas City line of the Rock Island-Milwaukee. (4 500 words & fig.)

1931 656 .255 (.73) & 656 .257 (.73)
Railway Signaling, November, p. 371.
BACON (A. R.). — **Centralized traffic control** on the Boston & Maine. (6 800 words & fig.)

1931 656 .258 (.73)
Railway Signaling, November, p. 381.
One **electric interlocking for two drawbridges.** (2 400 words & fig.)

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ZANE (W. F.). — The effect of Z. M. A. treated **ties on signal track circuits.** (2 300 words, tables & fig.)

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1931 621 .33
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Modern **railway practice and development.** Progress **of railway electrification.** (2 900 words.)

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STRAUSS (F.). — **Yugoslavian Railways.** General **review.** (1 500 words.)

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1931 385. (09.3 (.493)
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INZA (Carlos de). — Los **ferrocarriles belgas** en los últimos diez años. (4 600 palabras.)

Ferrocarriles y Tranvias. (Madrid.)

1931 656 .25
Ferrocarriles y Tranvias, Agosto, p. 171.
WINDAHL (E. G.). — **Aparato de maniobra eléctrica** con registro de enclavamiento eléctrico. (5 100 palabras & fig.)

1931 621 .4
Ferrocarriles y Tranvias, Septiembre, p. 219.
RIBERA (J. E.). — Los **automotores en ferrocarriles** (1 600 palabras & fig.)

1931 656 .213 (.460
Ferrocarriles y Tranvias, Septiembre, p. 223.
TOYOS (J. M.). — Los **puertos como estaciones ferroviarias.** El puerto de San Esteban de Pravia (1 700 palabras & fig.)

1931 621 .33 (.44
Ferrocarriles y Tranvias, Septiembre, p. 228.
La **electrificación** de ferrocarriles en Francia. (5 70 palabras.)

Gaceta de los Caminos de hierro. (Madrid.)

1931 669 .1

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Aceros especiales empleados en los ferrocarriles. (3 900 palabras.)

1931 621 .33 (.492)

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La tracción eléctrica en los ferrocarriles holandeses. (600 palabras.)

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1931 625 .142 .2

Ingenieria y Construccion, diciembre, p. 738.

CEBALLOS (R.). — Sobre las **maderas** utilizables **para traviesas de ferrocarril.** (1 500 palabras.)

Los Transportes. (Madrid.)

1931 621 .33 (.460)

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Las **electrificaciones** ferroviarias españolas. (3 300 palabras & fig.) (Continuará.)

Revista de Obras Públicas. (Madrid.)

1931 351 (.460)

Revista de Obras Públicas, nº 22, 15 de Noviembre, p. 463.

Sobre el proyecto de **ordenación ferroviaria.** (7 800 palabras.)

1931 624 .63 (.493)

Revista de Obras Públicas, nº 22, 15 de Noviembre, p. 470.

Puentes de hormigón armado en pórtico, construidos sobre el canal de Charleroi, en Bruselas, por el ingeniero de puentes y calzadas, M. Boucau. (1 800 palabras & fig.)

In Italian.

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1931 624 .2

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SESINI (O.). — Recenti esperienze sulle **sollecitazioni dinamiche nei ponti metallici.** (5 600 parole & fig.)

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1931 625 .236 (.45)

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Impianti per **pulizia radicale delle carrozze.** (1 400 parole & fig.)

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1931 656 .211.7 (.45)

Rivista tecnica delle ferrovie ital., 15 novembre, p. 265.

CORBELLINI (G.). — Miglioramenti recenti del **traghetto ferroviario attraverso lo stretto di Messina.** (5 400 parole & fig.)

1931 624 .6 (.45)

Rivista tecnica delle ferrovie ital., 15 novembre, p. 285.

BUSINARI (F.). — Il nuovo **viadotto** di Castellaneta sulla linea Bari-Taranto. (2 700 parole & fig.)

1931 621 .33 (.45) & 625 .175 (.45)

Rivista tecnica delle ferrovie ital., 15 novembre, p. 297.

OTTORINO (T.). — Mezzi di trasporto e di lavoro per la **revisione delle linee elettrificate.** (7 600 parole & fig.)

In Dutch.

De Ingenieur. (Den Haag.)

1931 621 .33 (.492)

De Ingenieur, nr 48, 27 November, p. 149.

VERSCHOOR (H. E.). — **Kosten** van den door Nederlandsche Spoorwegen **verbruikten electrischen stroom.** (1 400 woorden & fig.)

De Locomotief. (Amsterdam.)

1931 621 .43

De Locomotief, nr 22, 16 November, p. 171.

De **Micheline.** (3 100 woorden & fig.)

1931 625 .2 & 669

De Locomotief, nr 23, 1 December, p. 183.

Lichte metalen voor de constructie van **spoorrijtuigen.** (1 500 woorden & 3 tafereelen.)

Spoor- en Tramwegen. (Utrecht.)

1931 625 .253 (.4)

Spoor- en Tramwegen, nr 11, 24 November, p. 277; nr 12, 8 December, p. 308.

BOLLEMAN KIJLSTRA (E.). — De grondbeginselen der europeesche **luchtdrukremmen.** (2 400 woorden & fig.) (wordt vervolgd.)

1931 625 .13 (.92)

Spoor- en Tramwegen, nr 11, 24 November, p. 287.

SLIM (J.). — De **spoorwegbrug** over de Kali Batang in de lijn Djocjakarta-Magelang, in verband met de jongste Merapi-eruptie. (1 900 woorden & fig.)

1931 656 .211 (.43)

Spoor- en Tramwegen, nr 11, 24 November, p. 290.

OVERMANN (J.). — Bij het 25-jarig bestaan van het **hoofdstation** te Hamburg (5 December 1931). (1 300 woorden & fig.)

1931 656
Spoor- en Tramwegen, nr 12, 8 December, p. 301.
SIMON-THOMAS (W.). — Wetenschappelijke bedrijfsleiding en analyseering in het spoorwegbedrijf. (2 000 woorden.)

1931 625 .143.5
Spoor- en Tramwegen, nr 12, 8 December, p. 311.
MESTRAL DE COMBREMONT (P.). — Vergelijkende beproeving der nieuwe spoorstaafbevestiging door middel van spieën en klemmen, uitvoering N. V. Ougrée-Marihaye, te Ougrée bij Luik. (700 woorden & fig.)

In Portuguese.

Boletim do Instituto de Engenharia (S. Paulo). (Brasil.)

1931 62. (01
Boletim do Instituto de Engenharia, Setembre, p. 93.
TOLEDO PISA (A. P. de). — Sobre as derivadas do trabalho de deformação. (3 300 palavras.)

Gazeta dos Caminhos de ferro. (Lisboa.)

1931 385 .1 (.469)
Gazeta dos Caminhos de ferro, nº 1054, 16 de Novembro, p. 453.
SOUSA (J. F. de). — A reorganisação financeira da Companhia dos Caminhos de ferro portugueses. (1 800 palavras.)

Revista das Estradas de ferro. (Rio de Janeiro.)

1931 621 .33 (.81)
Revista das Estradas de ferro, nº 151, 30 de Outubro, p. 486; nº 152, 15 de Novembro, p. 506.
A electrificação da Central. (5 900 palavras.)

1931 625 .143.1
Revista das Estradas de ferro, nº 151, 30 de Outubro, p. 489.
Qual o trilho mais economico? (800 palavras & fig.)

In Polish.
(= 91 885.)

Inżynier Kolejowy. (Warszawa)

1931 621 .132.6 (.497.2) = 91 .885
Inzynier Kolejowy, No. 12, p. 323.
BRYLING. — 2-12-4 tank locomotives of the Bulgarian State Railways. (5 500 words & fig.)

1931 624 .32 (.438) = 91 .885
Inzynier Kolejowy, No. 12, p. 327.
SUSZYNSKI. — Construction of a bridge on the diametral line at Warsaw. (3 000 words & fig.)

1931 656 .257 = 91 .885
Inzynier Kolejowy, No 12, p. 330.
EBERHARDT (A.). — The M. D. M. all-electric system of centralised point operation. (2 600 words & fig.)

In Rumanian.
(= 599)

Revista C. F. R. (Bucuresti.)

1931 385 .113 (.498) = 599
Revista C. F .R., No. 10, p. 309.
RADOVICI. — Determination of the working costs on the Rumanian State Railways. (4 000 words & fig.)

In Serbian.
(= 91.882)

Saobraćajni Pregled. (Belgrad.)

1931 621 .133.8 (.497.1) = 91 .882
Saobracajni Pregled, No. 11, p. 462.
GREBENAROVIC. — The safety valves of the new standard gauge locomotives of the Yugoslav State Railways. (8 500 words & fig.)

1931 691 = 91 .882
Saobracajni Pregled, No 11, p. 471.
TURKALJ. — The supply and inspection of stone for the national transport undertakings, especially for the railways. (7 000 words.)

1931 656 .223 .2 = 91 .882
Saobracajni Pregled, No. 11, p. 484.
DOLINAR. — The « Owning System » in the interchange rules of the R. I. V. and R. I. C. (1 500 words.)

In Czech.
(= 91.886)

Železniční Revue. (Prague.)

1931 656 .1 (.437) = 91 .886
& 656 .2 (.437) = 91 .886
Zeleznicní Revue, No. 21, p. 321.
VONDRACEK-NEUMAN. — The economics of railway and road motor transport. A comparison. (4 500 words.)

1931 656 .25 = 91 .886
Zeleznicní Revue, No. 21, p. 327; No. 22, p. 340.
SVOBADA. — Some questions relating to the safety of railway working. Automatic locomotive cab repeater signals. Automatic train control. VI. Continuous control installations. (3 100 words & fig.)

Zprávy železničních inženýrů. (Prague.)

1931 62. (01 = 91 .886 & 669 = 91 .886
Zprávy zeleznicnich inzenyru, No. 11, p. 212.
PETRVALSKY. — Parkerisation as a rust preventive. (2 500 words & fig.)

955. — M. Weissenbruch Co., Ltd., Printer to the King, 49, rue du Poinçon, Brussels.

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[016 .385. (02]

I. — BOOKS.

In French.

1931 313 .385 (.438)

Annuaire statistique des Chemins de fer de l'Etat olonais pour l'exercice 1930.

Warszawa, Druk. Zakl. Graf. E. I D-ra K. Kozians- ich. Un volume, 273 pages, graphiques et 1 carte.

1932 691 & 693

EBÈS (G.), Ingénieur en chef des Ponts et Chaussées.

Maçonnerie, béton, béton armé.

Paris, Léon Eyrolles, Librairie de l'enseignement echnique. Un volume, 739 pages, 205 figures et 6 lanches. (Prix : 125 francs français.)

1932 656

UPUIS, Docteur en droit.

Le rail et l'aile.

Paris, Librairie des Sciences aéronautiques, 48, rue es Ecoles. Un volume (16.5 × 27 cm.), 210 pages. Prix : 25 francs français.)

1932 744. (02

Manuel de traçage et de chaudronnerie à l'usage des pprentis chaudronniers et ferblantiers.

Paris (6e), Desforges, Girardot & Cie, 27, 29, quai es Grands-Augustins. Un volume, 76 pages. (Prix : 2 francs français.)

1931 621 .83

ÉRIGNON (J.), Ingénieur.

Théorie et technologie des engrenages.

Tome I : Etude cinématique. Conventions usuelles. tude dynamique.

Paris (6e), Dunod, 92, rue Bonaparte. Un volume, 16 × 25 cm.), 278 pages, 188 figures. (Prix : 81 francs rançais.)

1931 313 : 656 .225 (.438)

Résumé général du tonnage des marchandises transportées par les Chemins de fer de l'Etat polonais pour l'exercice 1930.

Warszawa, Drukiem Zakladów Graficznych « Bibljoteka Polska » w Bydgoszczy. Un volume, 283 pages et graphiques.

1931 621 .43

SEILIGER.

Les moteurs Diesel sans compresseur et les moteurs semi-Diesel.

Traduit de l'Allemand par A. Schubert, Ingénieur.

Paris (6e), Dunod, 92, rue Bonaparte. Un volume (16 × 25 cm.), 471 pages et 375 figures. (Prix : 142 francs français.)

1931 385. (01 (.67)

VASSAL (Gabrielle & Joseph).

Français, Belges et Portugais en Afrique équatoriale. Pointe-Noire, Matadi, Lobito.

Paris, Roger, P. Un volume, 255 pages et cartes. (Prix : 15 francs.)

In German.

1931 624 .2

ARMBRUSTER, Eugen.

Einfluss der Oberflächenbeschaffenheit auf den Spannungsverlauf und die Schwingungsfestigkeit.

Berlin, Zeitschrift des Vereines deutscher Ingenieure Verlag. 1 Band, 64 Seiten, mit 106 Abbildungen. (Preis: 7 R.M.)

1931 385. (02 (.43)

BAUMANN (Hans).

Deutscher Reichsbahn-Kalender 1932.

Leipzig, Konkordia-Verlag. 1 Band. (Preis : 4 R.M.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH, in the number for November, 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

1932 621 .114

FALZ (E.).

Grundzüge der Schmiertechnik, Berechnung und Gestaltung vollkommen geschmierter gleitender Maschinenteile. Lehr- und Handbuch für Konstrukteure, Betriebsleiter, Fabrikanten und höhere technische Lehranstalten.

Leipzig, Johann Ambrosius Barth & Brüssel, Falk, Fils, rue des Paroissiens. 1 Band, 326 Seiten, 18 Zahlentafeln, 44 Berechnungsbeispiele und 121 Textabbildungen. (Preis : 26.50 R.M.)

1931 385. (09 .1 (.4)

Grosser Atlas der Eisenbahnen und Schiffahrt von Europa.

Leipzig, Johann Ambrosius Barth & Brüssel, Falk, Fils, rue des Paroissiens. 1 Band, 32 gänzlich neubearbeitete Auflage. (Preis : 50 R.M.)

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Le freinage avec récupération sur les voitures de tramways. (9 700 mots & fig.)

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HEUMANN. — **Spurkranz und Schienenkopf.** (5 600 Wörter & Abb.) (Schluss.)

1931 624 .7 (.433)
Organ für die Fortschritte des Eisenbahnwesens, Heft 24, 15. Dezember, S. 499.
HANS (F.). — Die **Wiesentbrücke** « Gleich und rund » in der Landschaft. (2 500 Wörter & Abb.)

1931 656 .254
Organ für die Fortschritte des Eisenbahnwesens, Heft 24, 15. Dezember, S. 503.
VAN BIEMA. — **Eisenbahnhochbau und Fernmeldeanlagen.** (2 800 Wörter & Abb.)

1932 625 .143.5
Organ für die Fortschritte des Eisenbahnwesens, Heft 1, 1. Januar, S. 1.
EICHER (G.). — Neues Verfahren zur Ermittlung der **Schienenwanderung.** (6 000 Wörter & Abb.)

1932 625 .14

Organ für die Fortschritte des Eisenbahnwesens, Heft 1, 1. Januar, S. 11.

BÄSELER. — Neue Zielrichtungen im **Oberbau.** (1 700 Wörter & Abb.)

1932 625 .14 (01

Organ für die Fortschritte des Eisenbahnwesens, Heft 1, 1. Januar, S. 14.

SALLER. — Einheitliche Berechnung des **Eisenbahnoberbaues.** (3 700 Wörter & Abb.)

Die Reichsbahn. (Berlin.)

1931 347 .763 (.497.1) & 656 .1 (497.1)

Die Reichsbahn, Nr. 48, S. 1086.

Kraftverkehrsrecht in Jugoslawien. (2 1/2 Seiten.)

1931 656 .231 (.43)

Die Reichsbahn, Nr. 51, S. 1173.

Die neue **Tarifermässigung** der Reichsbahn. (6 Seiten.)

Verkehrstechnische Woche. (Berlin.)

1931 656 .212.5

Verkehrstechnische Woche, Nr. 45, S. 593.

WERNER. — Das Längenprofil der Richtungsgleise in **Verschiebebahnhöfen.** (5 Seiten & Zeichn.)

1931 656 .1 (.43)

Verkehrstechnische Woche, Nr. 45, S. 599.

Verkehrsmittel untereinander. — Notverordnung über den **Kraftverkehr.** (2 Seiten.)

1931 656 .211

Verkehrstechnische Woche, Nr. 47, S. 617.

CAUER. — Gestaltung von **Personenbahnhöfen.** (3 Seiten.)

1931 656 .222 (.43)

Verkehrstechnische Woche, Nr. 49, S. 641.

HARTMANN. — **Schnellverkehr auf der Eisenbahn.** (3 Seiten.)

1931 621 .132.8

Verkehrstechnische Woche, Nr. 49, S. 644.

FLACHS. — Verwendung von **Schnelltriebwagen.** (3 Seiten & Diagr.)

1931 656 .225

Verkehrstechnische Woche, Nr. 49, S. 647.

EGGERT. — Beförderungsdienstliche **Zusammenfassung** von **Eil- und Frachtgut.** (1 Seite.)

1931 656 .212.5

Verkehrstechnische Woche, Nr. 50. S. 656.

MASCHKE. — Mittlere **Abdruckgeschwindigkeit** und ihre Steigerung durch Gleisbremsen. (4 Seiten, Zeichn. & Diagr.)

1931 656 .222.5

Verkehrstechnische Woche, Nr. 51, S. 665.

MESTWERDT. — **Beschleunigung der Personenzüge.** (4 Seiten & Diagr.)

1931 621 .392 & 625 .143.3

Verkehrstechnische Woche, Nr. 52, S. 677.

WATTMANN. — **Durchgehende Schweissung von Eisenbahngleisen.** (4 Seiten.)

Zeitschrift des Vereines Deutscher Ingenieure. (Berlin.)

1931 621 .135.3 & 625 .213

Zeitsch. des Ver. deutsch. Ing., Nr. 51, 19. Dezember, S. 1521.

STARK (H.). — **Untersuchungen an Blattfedern.** Zwischenbericht des Ausschusses für Federn beim Verein deutscher Ingenieure und beim Verein deutscher Eisenhüttenleute. (4 200 Wörter & Abb.)

1931 621 .114

Zeitsch. des Ver. deutsch. Ing., Nr. 51, 19. Dezember, S. 1539.

VON SCHROETER (H.). — Fragen der **Schmiertechnik.** (2 000 Wörter.)

1931 621 .132.1 (.497.2)

Zeitsch. des Ver. deutsch. Ing., Nr. 52, 26. Dezember, S. 1553.

OPITZ (R.). — Die neuen **Einheitslokomotiven** der **Bulgarischen Staatsbahn.** (1 400 Wörter & Abb.)

1931 62. (01

Zeitsch. des Ver. deutsch. Ing., Nr. 52, 26. Dezember, S. 1559.

BERNHARD (R.). — **Prüfstand** für Messgeräte im Bauwesen. (2 800 Wörter & Abb.)

1931 62. (01

Zeitsch. des Ver. deutsch. Ing., Nr. 52, 26. Dezember, S. 1565.

Versuche über die **Spannungsverteilung** im stark gekrümmten Träger. (1 200 Wörter & Abb.)

1932 62. (01 (.43)

Zeitschr. des Ver. deutsch. Ing. Nr. 2, 9. Januar, S. 30.

AMMANN (O.). — **Strassenprüfmaschine** des Instituts für Strassen- und Eisenbahnwesen der Technischen Hochschule Karlsruhe. (2 400 Wörter & Abb.)

1932 621 .114 & 625 .214

Zeitschr. des Ver. deutsch. Ing. Nr. 2, 9. Januar, S. 33.

ERK (S.). — **Schmieröle** bei tiefen **Temperaturen.** I. Bericht. (3 600 Wörter, 2 Tafeln & Abb.)

1932 623

Zeitschr. des Ver. deutsch. Ing. Nr. 2, 9. Januar, S. 41.

GOSSOW (E.) & SCHWENNINGER (O.). — Technische Fragen des **Luftschutzes.** (2 400 Wörter & Abb.)

1932 651
Zeitschr. des Ver. deutsch. Ing. Nr. 2, 9. Januar, S. 44.
BERGER (R.). — **Allgemeine Entwicklungsrichtungen der Büromaschinen.** (1 200 Wörter.)

1932 691
Zeitschr. des Ver. deutsch. Ing. Nr. 2, 9. Januar, S. 45.
HOFFMANN (R.). — **Betonieren unter Wasser** nach dem Contractor-Verfahren. (900 Wörter & Abb.)

1932 531
Zeitsch. des Ver. deutsch. Ing., Nr. 3, 16. Januar, S. 49.
SACHS (G.). — **Mechanik** der spanlosen Formung, Walzen, Pressen, Ziehen, usw. (4 500 Wörter & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1931 625 .245 & 656 .225
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 47, S. 1257.
SCHROEDER. — **Grossbehälterverkehr.** (6 Seiten & Zeichn.)

1931 656 .23 (0
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 48, S. 1273.
SPIESS. — Zur Erkenntnis des Begriffs : **Tarif.** (7 1/2 Seiten.)

1931 624 .6 (.43)
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 48, S. 1281.
TILS. — **Eisenbahndreigurtbrücke** in Düren. (3 1/2 Seiten, Zeichn. & Abb.)

1931 659 (.73)
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 48, S. 1284.
CHARITIUS. — Amerikanische **Werbemethoden** für die Eisenbahnen. (2 Seiten.)

1931 347 .762
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 49, S. 1297.
HAUSTEIN. — Zur Erkenntnis der Begriffe **Tarif** und **Kontrahierungszwang.** (4 Seiten.)

1931 656 .212.6
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 50, S. 1327.
PONTANI. — Die **Umladekrane** auf Güterbahnhöfen. (4 Seiten, Zeichn. & Abb.)

1931 625 .144
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 51, S. 1361.
WENTZEL. — **Vergrösserung des Gleisachsenabstandes** zweigleisiger Strecken auf 3.70 m. (2 1/2 Seiten & Zeichn.)

1931 656 .254
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 51, S. 1364.
DERIKARTZ. — Die **Eisenbahn-Läutewerke** und ihre Bedeutung im neuzeitlichen Eisenbahn- und Strassenverkehrswesen. (3 Seiten.)

1931 656 .1 & 656 .2
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 52, S. 1377.
BAESELER. — **Strasse und Schiene.** (2 1/2 Seiten.)

1931 656 .231 (.43)
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 52, S. 1380.
Tarifsenkungen der deutschen Bahnen, die im Zusammenhang mit den Preissenkungsmassnahmen der Deutschen Reichsregierung durchgeführt werden. (6 1/2 Seiten mit Diagr.)

In English.

Bulletin, American Railway Engineering Association. (Chicago.)

1931 347 .75 (.73)
Bul. Amer. Ry. Eng. Ass^{on}, October, p. 65.
Uniform general **contract forms.** Report of Committee XX. (20 000 words.)

1931 016 .656 .212 (.73) & 656 .212 (.73)
Bul. Amer. Ry. Eng. Ass^{on}, October, p. 113.
Yards and terminals. — Report of Committee XIV. (12 000 words & fig.)

Engineer. (London.)

1931 621 (06 (.42) & 625 .142.2
Engineer, No. 3962, December 18, p. 644.
The manufacture and use of **steel railway sleepers,** by Raymond CARPMAEL. Paper presented before the Institution of Mechanical Engineers. Discussion. (4 500 words.)

1931 625 .142.2
Engineer, No. 3962, December 18, p. 645; No. 3963, December 25, p. 671.
CARPMAEL (R.). — The manufacture and use of **steel railway sleepers.** (7 300 words, 1 table & fig.)

1931 621 .335 (.42) & 621 .43 (.42)
Engineer, No. 3962, December 18, p. 658.
250 B. H. P. **Oil-electric rail coach.** (2 400 words & fig.)

1931 621 .135
Engineer, No. 3962, December 18, p. 660.
A portable locomotive weighing machine. (350 words & fig.)

1932 621 .132.8
Engineer, No. 3963, December 25, p. 676.
GREEN (F. W.). — Use of **self-propelling vehicles for railway passenger traffic.** (2 500 words.)

1931 627
Engineer, No. 3963, December 25, p. 684.
A 60-ton floating crane for Cape Town. (550 words & fig.)

1931 698
Engineer, No. 3963, December 25, p. 684.
A paint spraying plant. (250 words & fig.)

1932 621 .3
Engineer No. 3964. January 1, p. 4; No. 3965, January 8. p. 38.
Electrical engineering in 1931. I. (5 500 words. 1 table & fig.)

1932 621
Engineer, No. 3964. January 1, p. 9.
Progress in prime movers in 1931. (3 000 words & fig.)

1932 621 .13
Engineer, No. 3964, January 1, p. 16.
Locomotives in 1931. (2 200 words & fig.)

1932 624
Engineer, No. 3964, January 1, p. 17.
Some bridges of 1931. (1 400 words.)

1932 535. (064 (.42)
Engineer, No. 3965, January 1, p. 40.
Physical and optical societies exhibition. (4 600 words & fig.)

1931 62. (01 & 669 .1
The Metallurgist, p. 184. Supplement to the Engineer, December 25.
PEARCE (J. G.). — The testing of castings. (2 200 words.)

1931 621 .392 & 621 .7
The Metallurgist. p. 186, Supplement to the Engineer, December 25.
Some electric thermostats and furnaces. (1 200 words & fig.)

Engineering. (London.)

1931 621 .98
Engineering, No. 3440, December 18, p. 760.
Hydraulically-operated cylinder-honing machine. (700 words & fig.)

1931 621 .31
Engineering, No. 3440, December 18, p. 773.
Developments in mercury-arc rectifiers and valves. (2 000 words & fig.)

1931 625 .142.3
Engineering. No. 3440, December 18, p. 775.
CARPMAEL (R.). — The manufacture and use of steel railway sleepers. (4 400 words & fig.)

1931 536
Engineering, No. 3441, December 25, p. 800.
JAKOB (M.). — Steam research in Europe and in America. (5 600 words & fig.)

1932 624 .62 (.73)
Engineering, No. 3442, January 1, p. 1; No. 3444, January 15, p. 59.
The superstructure of the Kill van Kull bridge I. (7 500 words & fig.)

1932 621.9 (.43)
Engineering, No. 3442, January 1, p.
Tendencies in German machine-tool design. (2 600 words & fig.)

1931 625 .31
Engineering, No. 3442, January 1, p. 7.
Tests of expansion and compressed-air circuit breakers. (600 words & fig.)

1932 621 .335 (.42) & 621 .43 (.42)
Engineering, No. 3442, January 1, p. 11.
250-H. P. oil-electric rail coach. (1 700 words & fig.)

1932 669
Engineering, No. 3442, January 1, p. 23; No. 3443, January 8, p. 54.
LEA (F. C.) & PARKER (C. F.). — The effect of temperature on some of the physical properties of metals. (5 000 words, 1 table & fig.)

1932 621 .116 & 669 .1
Engineering, No. 3442, January 1, p. 27.
High pressures and temperatures for steam prime movers. (1 400 & fig.)

1932 62. (01
Engineering, No. 3443, January 8, p. 29.
X-ray crystal analysis in industrial problems. (2 000 words & fig.)

1932 691
Engineering, No. 3443, January 8, p. 33.
The deterioration of structures in sea water. (1 400 words.)

1932 621 .134.1 (.42)
Engineering. No 3443, January 8, p. 38.
GRESLEY (H. N.). — Rebuilt 4-4-2 type locomotive with booster, London & North Eastern Ry. (900 words & fig.)

1932 625 .214 (.42)
Engineering, No. 3444, January 15, p. 66.
Roller bearing railway axle-boxes. (900 words & fig.)

Engineering News-Record. (New York.)

1931 656 .211.4
Engineering News-Record, No. 25, December 17, p. 961.
New Texas & Pacific terminals at Fort Worth. (3 000 words & fig.)

1931 624 .63 (.73)
Engineering News-Record, No. 26, December 24, p. 993.
Unique ribbed-arch bridge used for Parkway overpass. (1 400 words & fig.)

1931 625 .4 (.73)
Engineering News-Record, No. 26, December 24, p. 1001.
New York subway construction IV. — Steel erection and concreting methods. (2 200 words & fig.)

1931 691 & 693
Engineering News-Record, No. 26, December 24, p. 1024.
Precise concrete control at Koon Dam. (2 700 words & fig.)

Journal of the Institute of Transport. (London.)

1932 627 (.42)
Journal, Institute of Transport, January, p. 107.
ROSS-JOHNSON (D.). — English port ownership and control. (18 500 words.)

1932 656
Journal Institute of Transport, January, p. 127.
PLANT (A.). — Competition and co-ordination in transport. (8 700 words.)

1932 621 .43 & 656 .1
Journal, Institute of Transport, January, p. 137.
CROOKE (S. E.). — The possibilities of the Diesel engine for road transport. (6 400 words.)

Mechanical Engineering. (New York.)

1932 621 .338 (.73) & 625 .26 (.73)
Mechanical Engineering, January, p. 41.
Improved rapid-transit cars. (4 300 words, 3 tables & fig.)

Modern Transport. (London.)

1931 385 .1 (.56)
Modern Transport, No. 667, December 26, p. 3.
Railways in Palestine. Operating difficulties from lack of funds. (1 700 words & fig.)

1931 621 .134.1
Modern Transport, No. 667, December 26, p. 4.
London & North Eastern Railway locomotives equipped with boosters. (1 200 words & fig.)

1931 621 .33 (.42)
Modern Transport, No. 667, December 26, p. 6.
Electrification of main line railways. Some outstanding considerations. (1 200 words.)

1932 656 .211.5 (.42)
Modern Transport, No. 668, January 2, p. 5.
Ribbon storage train describers. (2 200 words & fig.)

1932 621 .335 & 621 .43
Modern Transport, No. 668, January 2, p. 7.
Diesel-electric shunting locomotives for employment in Ford Works. (1 100 words & fig.)

1932 656 .235
Modern Transport, No. 668, January 2, p. 8.
Addressing and labelling of goods. (1 500 words.)

1932 624 .32 (.66)
Modern Transport, No. 669, January 9, p. 3.
New bridge over the Benue River. (1 000 words & fig.)

1932 656 .2
Modern Transport, No. 669, January 9, p. 4.
Problem of rail traffic working. (1 500 words.)

1932 621 .13 (0
Modern Transport, No. 669, January 9, p. 5.
Locomotive engineering and operating. Some necessary improvements in design. (1 300 words.)

1932 656 .22 (.42)
Modern Transport, No. 669, January 9, p. 6.
Slip coach services on British railways. A diminishing practice. (1 100 words.)

1932 656 (.85)
Modern Transport, No. 669, January 9, p. 6.
Transport developments in Peru. Rail and road schemes. (800 words.)

1932 656 .25 (0
Modern Transport, No. 669, January 9, p. 7.
Economies from power signalling. (900 words.)

1932 656 .26 (.42)
Modern Transport, No. 669, January 9, p. 8.
Overhead of electric rolling stock. (1 200 words.)

1932 656 .212.5 (.42)
Modern Transport, No. 670, January 16, p. 3.
MAULDIN (H. H.). — Mechanised marshalling yards. Advantages achieved at Whitemoor. (4 300 words.)

1932 621 .43 & 625 .24
Modern Transport, No. 670, January 16, p. 5.
Freight rolling stock for Bermuda Railway. Motor coaches and trailers. (750 words & fig.)

1932 385 .21 (.42)
Modern Transport, No. 670, January 16, p. 12.
Present position of British canals. Problem of railway-owned waterways. (1 600 words & 3 tables.)

Proceedings, American Society of Civil Engineers. (New York.)

1931 624 .2
Proc. Amer. Soc. Civil Eng., November, p. 1355.
LARGE (G. E.), THOMPSON (S.) & CUTLER (R. W.). — Analysis of continuous frames by distributing fixed-end moments. (Discussion.) (1 700 words, tables & fig.)

1931 624 .63
Proc. Amer. Soc. Civil Eng., November, p. 1389.
NORD (Ch. L.), KEYSER (F. W.) & EREMIN (A. A.). — **An analysis of multiple-skew arches on elastic piers.** (3 200 words, tables & fig.)

1931 624 .62 (.73)
Proc. Amer. Soc. Civil Eng., December, p. 1467.
SPOFFARD (Ch. M.). — **Lake Champlain bridge.** (13 000 words, tables & fig.)

1931 624
Proc. Amer. Soc. Civil Eng., December, p. 1501.
REICHMANN (A. F.). — **Construction plant and methods for erecting steel bridges.** (5 800 words & fig.)

1931 625 .13 (.73)
Proc. Amer. Soc. Civil Eng., December, p. 1517.
KILLMER (M. J.). — **Fulton Street. East River tunnels, New York, N. Y.** (3 700 words & fig.)

Proceedings, Institution of Railway Signal Engineers. (Reading).

1931 656 .257
Proc. Inst. Ry. Signal Eng., Part I, January to October, p. 12.
BAKER (E. W.). — **The installation of double wire interlocking on the Assam-Bengal Railway.** (Paper and Discussion.) (20 000 words & fig.)

1932 656 .253
Proc. Inst. Ry. Signal Eng., Part I, January to October, p. 79.
LASCELLES (T. S.). — **A contribution to the question of route lever working.** (Paper and Discussion.) (18 000 words.)

1931 656 .253
Proc. Inst. Ry. Signal Eng., Part I, January to October, p. 122.
CROOK (G. H.). — **Ethics and economics of speed signalling.** (Paper and Discussion.) (16 500 words & fig.)

1931 656 .257
Proc. Inst. Ry. Signal Eng., Part I, January to October, p. 168.
CHALLIS (W.). — **Electric lever interlocking and intermittent fed track circuits.** (Paper and Discussion.) (7 300 words & fig.)

Railway Age. (New York.)

1931 651
Railway Age, No. 23, December 5, p. 852.
Reducing expenses in the office. (2 400 words & fig.)

1931 656 .212.6 (.73)
Railway Age, No. 23, December 5, p. 855.
Providing enlarged facilities for coal and ore. (4 200 words & fig.)

1931 656 .255 (.73)
Railway Age, No. 23, December 5, p. 861.
BACON (A. R.). — **Centralized traffic control on the Boston & Maine.** (3 800 words & fig.)

1931 656 .256.2 (.73)
Railway Age, No. 24, December 12, p. 890.
Automatic interlockings reduce operating expenses. (2 600 words & fig.)

1931 621 .335 (.73 & 621 .43 (.73)
Railway Age, No. 24, December 12, p. 893.
Seven oil-electric locomotives for terminal switching service. (1 600 words & fig.)

1931 625 .162 (.73)
Railway Age, No. 24, December 12, p. 896.
BLAKE (H. D.). — **Combatting unemployment with a grade separation program.** (3 400 words & fig.)

1931 385 .3 (08 (.73)
Railway Age, No. 24, December 12, p. 900.
Interstate Commerce Commission submits annual report. (7 200 words.)

1931 625 .29 & 656 .1
Railway Age, No. 25, December 19, p. 928.
Containers save money for shippers and the railroads. (3 900 words & fig.)

1931 625 .143.3 (.73) & 625 .172 (.73)
Railway Age, No. 25, December 19, p. 939.
New process retards rail batter. (1 500 words & fig.)

1931 656 .255 (.73)
Railway Age, No. 25, December 19, p. 944.
FULLER (D. W.). — **Centralized traffic control saves time on the Santa Fe.** (1 700 words & fig.)

1931 625 .142.2 (.73) & 691 (.73)
Railway Age, No. 26, December 26, p. 966.
Dollars spent for treated wood are returned manifold. (2 900 words & fig.)

1931 62. (01 (.73)
Railway Age, No. 26, December 26, p. 969.
RIPLEY (C. T.). — **The problems and possibilities of railway research.** (2 600 words & fig.)

1931 385 .3 (.73)
Railway Age, No. 26, December 26, p. 973.
General W. W. Atterbury analyzes Interstate Commerce Commission recommandations. (1 700 words.)

1931 621 .132.5 (.73)
Railway Age, No. 26, December 26, p. 975.
Western Pacific operating 2-8-8-2 types in fast-freight service. (1 000 words, 1 table & fig.)

1931 385 .31
Railway Age, No. 26, December 26, p. 977.
JACK (E. A.). — **Bureaucracy's increasing power threatens private ownership.** (4 000 words.)

1931 385 .1 (.73)
Railway Age, No. 26, December 26, p. 981.
Efforts to avert receiverships. (4 200 words.)

1931 656 .261 (.73)
Railway Age, No. 26, December 26, p. 985.
Trucks replace trap cars on the Milwaukee. (1 900 words & fig.)

1931 656 .1 (.73)
Railway Age, No. 26, December 26, p. 988.
North Western buses supplement train service. (1 800 words & fig.)

1932 385 .1
Railway Age, Annual Statistical Number, January 2, p. 8.
AISHTON (R. H.). — How to solve the railroad problem. (800 words & portrait.)

1932 385 .113 (.73)
Railway Age, Annual Statistical Number, January 2, p. 10.
PARMELEE (J. H.). — A review of railway operations in 1931. (7 000 words, 12 tables & portrait.)

1932 385 (0 (.71)
Railway Age, Annual Statistical Number, January 2, p. 19.
LYNE (J. G.). — Canada weighs railways' future. (2 900 words & fig.)

1932 385 .113 (.725)
Railway Age, Annual Statistical Number, January 2, p. 22.
Drastic retrenchment marked year on Mexican Railways. (2 500 words & fig.)

1932 313 : 625 .1 (.71 + .73)
Railway Age, Annual Statistical Number, January 2, p. 25.
BOYD (G. E.). — Mileage of new lines increases. (Statistics of new lines, lines abandoned, etc.) (2 200 words, tables & fig.)

1932 313 : 621 .139 (.73), 313 : 625 .18 (.73) & 313 : 625 .27 (.73)
Railway Age, Annual Statistical Number, January 2, p. 35.
STEEL (D. A.). — Prices of railway materials further reduced in 1931. (2 500 words, tables & fig.)

1932 313 : 621 .13 (.71 + .73)
Railway Age, Annual Statistical Number, January 2, p. 42.
TAFT (W. J.). — Locomotives ordered in 1931. (1 000 words, tables & fig.)

1932 313 : 625 .23 (.71 + .73)
Railway Age, Annual Statistical Number, January 2, p. 931.
HUDSON (G. C.). — Passenger car orders in 1931. (900 words, tables & fig.)

1932 313 : 625 .24 (.71 + .73)
Railway Age, Annual Statistical Number, January 2, p. 47.
KRAEGER (F. W.). — Freight cars ordered in 1931. (1 100 words, tables & fig.)

1932 385 .1 (.73)
Railway Age, Annual Statistical Number, January 2, p. 51.
LYNE (J. G.). — Railway finances in 1931. (2 300 words, tables & charts.)

1932 313 : 656 .25 (.71 + .73)
Railway Age, Annual Statistical Number, January 2, p. 57.
DUNN (J. H.). — Signaling construction during 1931. (2 700 words, tables & fig.)

1932 313 : 656 .1 (.71 + .73)
Railway Age, Annual Statistical Number, January 2, p. 71.
EMERY (J. C.). — Wider use of trucks dominant in motor transport. (1 800 words, table & fig.)

1932 313 : 621 .43 (.71 + .73)
Railway Age, Annual statistical Number, January 2, p. 68.
RICHARDSON (M. B.). — Thirty rail-motor cars ordered last year. (700 words, tables & fig.)

Railway Engineer. (London.)

1932 621 .132.1 (.52 + .68)
Railway Engineer, January, p. 6.
Recent locomotives for South Africa and China. (450 words.)

1932 621 .131.2
Railway Engineer, January, p. 7.
MIALL (S.). — Factors affecting the thermal efficiency of the steam engine. III. (4 800 words.)

1932 621 .392 (.42) & 625 .143.3 (.42)
Railway Engineer, January, p. 11.
A successful crossing welding application. (500 words & fig.)

1932 625 .143.5 (.42)
Railway Engineer, January, p. 12.
YATES (C. R.). — A two-way clamp for steel and cast-iron sleepers. (400 words & fig.)

1932 625 .29 & 656 .212.6
Railway Engineer, January, p. 13.
COPPOCK (C.). — Mobile trucks for railway use. I. (1 300 words.)

1932 625 .143.3
Railway Engineer, January, p. 14.
INGLIS (R. J. M.). — The wearing properties of old rails. (3 300 words & fig.)

1932 621 .335 (.42) & 621 .43 (.42)
Railway Engineer, January, p. 25.
New **Diesel-electric rail cars.** (2 200 words & fig.)

1932 621 .33 (.92)
Railway Engineer, January, p. 28.
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Oil-electric switchers for the Bush Terminal, New ork. (1 600 words, 1 table & fig.)

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VAN ROGGEN (J.). — **Trein en autobus.** (2 100 woorden & fig.)

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ARTHURTON (A. W.). — Electrificatie van hoofdspoorwegen in Groot-Brittannië. (2 400 woorden & fig.)

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Ferrovias e rodovias. A extinção do Directoria de Estr. de Rodagem do Estado. (6 100 palavras.)

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LOPES GALVAO. — A rêde de Marrocos com a bitola de 0 m. 60. (2 400 palavras & fig.)

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In Rumanian.

(= 599)

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VATAMANU. — High-pressure locomotive. (10 000 words, fig. & diagr.)

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JAKSEVAC. — The calculation and the use of the tractive power of goods train locomotives on maximum gradients. (9 000 words & diagr.)

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In Czech.

(91.886)

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12.120 — M. Weissenbruch Co., Ltd., Printer to the King, 49, rue du Poinçon, Brussels.

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In French.

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Calcul rapide des pièces fléchies en béton armé.

Bruxelles, Bieleveld, 66, rue Montagne-aux-Herbes-otagères. Une brochure, 48 pages, 21 figures et 7 aques. (Prix : 25 francs.)

1932 — 62. (03

EMAND (L.), professeur.

Nouveau lexique technique allemand-français et fran-is-allemand.

Paris et Liége, Librairie polytechnique, Ch. Béranger. volume, 308 pages. (Prix : 75 francs français.)

1932 — 621 .31

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Paris, J. B. Baillière et Fils. Un volume, 728 pages 302 figures. (Prix : 110 francs français.)

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Le Nord, étude historique et technique d'un grand seau français.

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1932 — 691 & 721 .9

Règlement sur les constructions en béton armé éta-i par la Commission d'Etudes Techniques de la ambre syndicale.

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Paris (6^e^), Dunod, 92, rue Bonaparte. Un volume, 590 pages (19 × 28 cm.). (Prix : 210 francs français.)

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Dauerfestigkeit von Stählen mit Walzhaut, ohne und mit Bohrung, von Niet- und Schweissverbindungen.

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New York. Published by Longmans Green & Co. (5 1/2 × 9 inches), 240 pages. (Price : $ 5.00.)

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South African Railways and Harbours. Report of the General Manager of Railways and Harbours for the year ended 31st March, 1931.

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Transporting the American Expeditionary Forces in Western Europe, 1917-1919.

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1932 — 656

Bull. techn. de la Suisse romande, n° 2, 23 janvier, p. 18.

CHOISY (E.-G.). — **Transports en commun.** (1 800 mots & fig.)

1932 — 691 (.494)

Bull. techn. de la Suisse romande, n° 4, 20 février, p. 45.

PARIS (A.). — Projet de revision des **normes suisses du béton et du béton armé.** (5 200 mots & fig.)

Chronique des transports. (Paris.)

1932 — 385. (09 (.73)

Chronique des transports, 25 janvier, n° 2, p. 4.

La **situation des chemins de fer** des Etats-Unis. (3 600 mots.)

1932 — 385 .517.7 (.44)

Chronique des transports, 10 février, n° 3, p. 8.

Le **logement du personnel** dans les chemins de fer français. (1 000 mots.)

Ferrovia. (Bruxelles.)

1932 — 621 .138.2 (.493)

Ferrovia, janvier, p. 10.

Les installations de **mélange de charbons** menus de la Société Nationale des Chemins de fer belges. (3 700 mots & fig.) (A suivre.)

Génie civil. (Paris.)

1932 — 625 .5 (.44)

Génie Civil, n° 2580, 23 janvier, p. 81.

LÉVY-LAMBERT. — **Le funiculaire aérien** pour voyageurs de Chamonix à la montagne du Brévent. (4 800 mots & fig.)

1932 — 624 .2

Génie Civil, n° 2580, 23 janvier, p. 87.

FONTVIOLANT (Bertrand de). — Influence de l'effort tranchant sur les **flèches élastiques des poutres.** (4 500 mots & fig.)

1932 669
Génie Civil, n° 2580, 23 janvier, p. 93; n° 2581, 30 janvier, p. 116.

La structure des métaux et alliages. La micrographie et la spectrographie aux rayons X. (6 800 mots.)

1932 625 .4
Génie Civil, n° 2580, 23 janvier, p. 97.

Dispositif pour augmenter le **débit des chemins de fer métropolitains** sans quadrupler les voies. (500 mots & fig.)

1932 62. (01 & 621 .39
Génie Civil, n° 2580, 23 janvier, p. 98.

ROSENTHAL (D.). — Augmentation de la résistance aux chocs répétés des **pièces assemblées par soudure.** (300 mots & fig.)

1932 624 .2 (01
Génie Civil, n° 2581, 30 janvier, p. 113.

WOLKOWITSCH (D.). — Les lignes d'influence d'une **poutre continue.** (2 700 mots & fig.)

1932 691
Génie Civil, n° 2582, 6 février, p. 137.

MARCOTTE (E.). — L'emploi, les propriétés et les applications des **ciments alumineux** (ciment fondu). (5 200 mots.)

1932 656 .213
Génie Civil, n° 2583, 13 février, p. 161.

Le XV^e Congrès International de Navigation (Venise, 12-29 septembre 1931). (Suite.) II^e section. Navigation maritime. 1re question. — **Lignes de chemins de fer et chemins de fer funiculaires d'accès aux ports; installations ferroviaires dans les ports.** (1 500 mots & fig.)

1932 624 .9 (.45)
Génie Civil, n° 2583, 13 février, p. 168.

Le montage de la **charpente** de la nouvelle gare centrale de Milan. (300 mots & fig.)

1932 624 .32 (.437) & 621 .392 (.437)
Génie Civil, n° 2583, 13 février, p. 171.

Pont-route de 50 mètres, soudé à l'arc, des Usines Skoda, à Pizen. (Tchécoslovaquie). (500 mots & fig.)

1932 624 .2
Génie Civil, n° 2584, 20 février, p. 192.

MESNAGER (A.). — La **flèche élastique d'une poutre** dépend-elle de l'effort tranchant ? (1 800 mots.)

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1932 621 .133.7
La Science et la Vie, février, p. 162.

Un nouveau **réchauffeur de l'eau d'alimentation** des locomotives .(700 mots & fig.)

La Traction électrique. (Paris.)

1931 621 .332
La Traction Electrique, septembre, p. 211.

PONTECORVO (L.). — Un système longitudinal autocompensé de **ligne de contact** à caténaires croisées. (8 600 mots & fig.)

1931 621 .335 (.494)
La Traction Electrique, septembre, p. 223.

ZEHNDER-SPOERRY (R.). — **Locomotives B_0-B_0-B_0** pour le Chemin de fer Montreux-Oberland bernois (1 800 mots.)

1931 625 .5 (.44)
La Traction Electrique, septembre, p. 227.

REBUFFEL (A.). — **Le téléphérique** à grande portée de Planpraz, au sommet du Brévent (Chamonix). (2 500 mots & fig.)

1931 625 .62 (.432)
La Traction Electrique, septembre, p. 233.

TITTELBACH (F.). — **Motrice** à quatre essieux de la Société anonyme des Tramways de Dresde. (3 700 mots & fig.)

Les Chemins de fer et les Tramways. (Paris.)

1932 625 .13 (.44)
Les Chemins de fer et les Tramways, janvier, p. 2.

Aération d'un tunnel de la ligne P.-L.-M. Bourg-Bellegarde. (1 600 mots & fig.)

1932 621 .133.3 & 621 .134.3
Les Chemins de fer et les Tramways, janvier, p. 3.

Chaudière à haute pression pour locomotives. (1 000 mots & fig.)

1932 621 .114
Les Chemins de fer et les Tramways, janvier, p. 5.

BRILLIÉ (H.). — Les phénomènes de viscosité et le **graissage.** (11 500 mots & fig.)

1932 625 .162 (.44)
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DUCHESNOY. — La suppression des **passages à niveau** de la région parisienne. (5 400 mots.)

1932 621 .133.7
Les Chemins de fer et les Tramways, janvier, p. 16

Réchauffeur d'eau d'alimentation. (500 mots & fig.)

1932 621 .83
Les Chemins de fer et les Tramways, janvier, p. 17

La technique et le taillage des **engrenages** à vis sans fin. (3 600 mots & fig.)

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1932 625 .13 (.44)
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OUDOTTE. — Note sur les travaux de **consolidation du viaduc** du Grand Echaud (Ligne de Longeray à Divonne). (7 000 mots & fig.)

1932 621 .135.3 (.44) & 625 .213 (.44)
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KŒNIGER. — Note sur la réparation et la con-
ection des **ressorts à lames** aux Chemins de fer d'Al-
ace et de Lorraine. (3 200 mots & fig.)

1932 385. (09 (.51)
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LAVIALLE D'ANGLARDS (H.). — La question des
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1932 313 .385 (.44)
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Résultats obtenus en 1930 sur le réseau des Che-
ins de fer de l'Etat, en France, d'après les comptes
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1932 385. (09 (.59)
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Situation actuelle des chemins de fer de l'Indochine.
5 600 mots & carte.)

1932 621 .33 (.436 + 437 + 439)
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1932 33
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COLSON (C.). — **L'assistance d'Etat aux chômeurs.**
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1932 621 .13 (06 (.44) & 625 .2 (06 (.44)
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MAGNÉE (P.). — Le **matériel** de la Compagnie des
hemins de fer du Nord figurant à l'Exposition Co-
niale de Vincennes, 1931. (3 500 mots & fig.)

In German.

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1932 621 .33 (.43)
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WECHMANN (W.). — Der **elektrische Zugbetrieb**
r Deutschen Reichsbahn. Neue Bauarbeiten und Be-
haffungen. (6 000 Wörter & Abb.)

1932 621 .335
lektrische Bahnen, Januar, S. 10.
PFLANZ (K.). — Über den mechanischen Aufbau
n **elektrischen Lokomotiven** der Achsfolge B + B.
300 Wörter & Abb.)

1932 621 .33
Elektrische Bahnen, Januar, S. 15.
NIBLER (H.) & SCHÄTZL (J.). — Verhalten von **Fahrleitungen** für elektrische Vollbahnen in Gleiskrümmungen unter dem Einfluss der Temperaturänderungen. (5 000 Wörter & Abb.)

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1932 38
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MOMBER (W.). — Die Technik in der **Wirtschaftskrise.** (7 800 Wörter & Abb.)

1932 621 .138.5 (.43)
Glasers Annalen, Nr. 1310, 15. Januar, S. 13.
ILTGEN. — Neues **Verfahren zum Vermessen von Lokomotivrahmen und Kreuzkopfgleitbahnen.** (3 100 Wörter & Abb.)

1932 625 .174
Glasers Annalen, Nr. 1311, 1. Februar, S. 26.
METZELTIN. — **Schneepflug** Bauart Klima. (1 000 Wörter & Abb.)

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1932 625 .142
Organ für die Fortschritte des Eisenbahnwesens, Heft 4, 15. Februar, S. 75.
VOGEL (R.). — Gesetzmässigkeiten beim **Ausbau von Eisenbahnschwellen.** (13 600 Wörter, 5 Tafeln & Abb.)

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1932 691 & 721 .9
Zeitsch. des Ver. deutsch. Ing., Nr. 5, 30. Januar, S. 97.
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1932 669
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SCHULZE (A.). — Über die **Umwandlungen von Metallen.** (5 700 Wörter & Abb.)

1932 621 .392 & 624 .92
Zeitsch. des Ver. deutsch. Ing., Nr. 6, 6. Februar, S. 121.
SCHMUCKLER (H.). — Neuere **geschweisste Stahlbauten.** (2 800 Wörter & Abb.)

1932 621 .43 (.64)
Zeitsch. des Ver. deutsch. Ing., Nr. 6, 6. Februar, S. 137.
STAMM (O.). — 150 **PS-Dieselgetriebe-lokomotive** für Marokko. (1 400 Wörter & Abb.)

1932 721 .9
Zeitsch. des Ver. deutsch. Ing., Nr. 7, 13. Februar, S. 151.
RAUSCH (E.). — Neuere **Eisenbetonkonstruktionen.** (4 200 Wörter & Abb.)

1932 62. (01 & 669 .1
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RÖTSCHER (F.) & FINK (M.). — Beitrag zur Kerbzähigkeit hochwertiger **Baustähle.** (3 800 Wörter & Abb.)

1932 621 .392
Zeitsch. des Ver. deutsch. Ing., Nr. 8, 20. Februar, S. 185.
SANDELOWSKY (S.). — Erkenntnisse über die **Schweissung** mit dem Kohlenlichtbogen. (2 000 Wörter & Abb.)

1932 621 .43 (.43)
Zeitsch. des Ver. deutsch. Ing., Nr. 8, 20. Februar, S. 188.
Motor-Kleinlokomotiven der Deutschen Reichsbahn, Baujahr 1931. (1 000 Wörter, 2 Tafeln & Abb.)

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1932 385. (09 (.3)
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 1, 7. Januar, S. 1; Nr. 2, 14. Januar, S. 33.
WULFF (D.). — **Rückblick auf das Jahr 1931.** (38 000 Wörter.)

1932 656 .235.5 (.43)
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 2, 14. Januar, S. 47.
ADOLPH. — Die neuen **Ermässigungen in den deutschen Kohlentarifen.** (900 Wörter & Abb.)

1932 385 .524 (.43)
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 3, 21. Januar, S. 61; Nr. 5, 4. Februar, S. 114.
FESSER. — Die **Kohlenprämie im Lokomotivbetrieb** der Eisenbahnen des Saargebiets. (9 500 Wörter).

1932 385. (09 (.92)
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 3, 21. Januar, S. 67.
REITSMA (S. A.). — Die **Eisenbahnen** in Niederländisch-Ostindien. (1 500 Wörter & Karten.)

1932 656 .225 (.43)
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 4, 28. Januar, S. 81.
LOHSE. — **Zusammenfassung von Eilstückgut und Frachtstückgut.** Eine beförderungsdienstliche Studie unter besonderer Berücksichtigung der Verhältnisse im Reichsbahndirektionsbezirk Hannover. (3 700 Wörter.)

1932 625 .23
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 4, 28. Januar, S. 85.
DIEDRICH. — Wirtschaftliche Ausnutzung der **Personenwagen.** (1 800 Wörter & Abb.)

1932 385. (09 .3 (.431)
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 5, 4. Februar, S. 105.
REMY. — **Berliner Stadtbahn-Jubiläum** 1882-1932. (3 500 Wörter & Abb.)

1932 656 .254
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 6, 11. Februar, S. 136.
GLÄSEL. — Zur Systemfrage bei der **Zugbeeinflussung.** (900 Wörter.)

1932 656 .21
Zeitung des Vereines deutsch. Eisenbahnverw., Nr. 6, 11. Februar, S. 137.
MARTIN (K.). — Bildliche Darstellung der **Betriebsvorgänge auf Bahnhöfen.** (1 400 Wörter & Abb.)

1932 621 .43 (.43)
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BREUER (M.). — Neuere **Triebwagen mit Verbrennungsmotoren.** (1 000 Wörter & Abb.)

1932 656 .225 (.43)
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JÖSCH. — **Leig-Züge.** (1 500 Wörter.)

1932 385 .1 (.44)
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Die **Lage der französischen Eisenbahnen** und Bestrebungen zu ihrer Besserung. (1 900 Wörter.)

In English.

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1931 347 .75 (06 (.73)
Bull., Amer. Ry. Eng. Ass^on, November, p. 149.
Report of special Committee on **standardization.** (3 800 words & appendices.)

1931 625 .144.4 (.73) & 625 .17 (.73)
Bull., Amer. Ry. Eng. Ass^on, November, p. 161.
Report of special Committee on **maintenance of way work equipment.** (8 900 words, tables & fig.)

1931 656 .2 (.73)
Bull., Amer. Ry. Eng. Ass^on, November, p. 193.
Report of Committee on **economies of railway operation.** (3 700 words & fig.)

1931 626 (.73), 627 (.73) & 656 .212 (.73)
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Report of Committee on **rivers and harbors.** (12 200 words & fig.)

1931 624 (.73)
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Report of Committee on wooden **bridges and trestles.** (3 700 words & fig.)

1931 614 .7 (.73) & 621 .133.7 (.73)
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Report of Committee on **water service and sanitation.** (10 200 words & fig.)

1931 625 .12 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, December, p. 297.
Report of Committee on **roadway.** (9 900 words & fig.)

1931 385 .587 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, December, p. 337.
Report of Committee on **rules and organization.** (3 800 words.)

1931 625 .141 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, December, p. 349.
Report of Committee on **ballast.** (5 700 words.)

1931 691 (.73)
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Report of Special Committee on **waterproofing of railway structures.** (450 words.)

1931 625 .14 (01 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, December, p. 369.
Report of Special Committee in **railroad track.** (800 words.)

1932 385 .58 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, January, p. 371.
Report of Committee on **economics of railway labor.** (13 500 words & fig.)

1932 725 .3 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, January, p. 405.
Report of Committee on **buildings.** (12 000 words & fig.)

1932 621 .138 (.73) & 725 .33 (.73)
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1932 625 .142 (.73)
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Report of Committee on **ties.** (3 300 words & fig.)

1932 625 .162 (.73) & 656 .254 (.73)
Bull., Amer. Ry. Eng. Ass^{on}, January, p. 497.
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1932 656 .25 (.73)
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Report of Committee on **signals and interlocking.** (1 800 words.)

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1932 656 .212.5
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Lay-out of **hump shunting yards.** (4 400 words & fig.)

1932 721 .31 (.45)
Engineer, No. 3967, January, 22, p. 93.
The new central railway station at Milan. (2 400 words & fig.)

1932 625 .1 (.42)
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British railways in 1931. (4 000 words.)

1932 621 .116
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The « Flamma » **smoke consumer.** (1 200 words & fig.)

1932 621 .335 & 621 (.43)
Engineer, No. 3968, January 29, p. 121.
The status of the **oil-electric locomotive.** (2 500 words & table.)

1932 621 .132.3 (.42)
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TUPLIN (W. A.). — The trend of **British express locomotive design.** (5 800 words.)

1932 621 .335
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TWINBERROW (J. D.). — The **mechanism of electric locomotives.** Paper read before the Institution of Mechanical Engineers. (1 800 + 4 800 words & fig.)

1932 614 .7 (.42)
Engineer, No. 3970, February 12, p. 176.
KERSHAW (J. B. C.). — **Air pollution** in 1930-31. (2 400 words, tables & fig.)

1932 624 (.42)
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New **railway bridge** over the North Circular Road. (2 700 words & fig.)

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1932 669 .1
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BRAMLEY (A.) & ALLEN (K. F.). — The **loss of carbon from iron and steel** when heated in decarburising gases. (6 200 words & fig.)

1932 621 .132.1 (.44)
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LORD MONKSWELL. — Recent railway **locomotive work in France.** (6 300 words & fig.)

1932 625 .1 (.56)
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Railway construction in Asia Minor. (6 600 words & fig.)

1932 656 .212.6 (.42)
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Portable **coal handling and weighing plant.** (1 400 words & fig.)

1932 — 62. (01 & 669 .1

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HANKINS (G. A.) & BECKER (M. L.). — **The fatigue resistance of spring steels.** (6 200 words, tables & fig.)

1932 — 621 .97 (.42)

Engineering, No. 3446, January 29, p. 145.

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1932 — 656

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1932 — 621 .335

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1932 — 669 .1

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Aluminium-silicon alloys as piston materials. (1 000 words & fig.)

1932 — 621 .92 (.42)

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Double-disc **sanding machines.** (750 words & fig.)

1932 — 669 .4 & 669 .6

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JAKEMAN (C.) & BARR (G.). — Tests on **tin-base and lead-base bearing metals.** (3 900 words, tables & fig.)

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1932 — 624 .51 (.73)

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Speedy **erection of parallel-strand cable bridge.** (3 400 words & fig.)

1932 — 625 .143.1 (.73)

Engineering News-Record, No. 2, January 14, p. 54.

Notable features found in **Pennsylvania's 152 lb. rail.** (1 600 words, 1 table & fig.)

1932 — 621 .392 & 69

Engineering News-Record, No. 3, January 21, p. 94.

McKIBBEN (F. P.). — Estimating **field-widening on multi-story buildings.** (800 words & 3 tables.)

1932 — 624 .2

Engineering News-Record, No. 4, January 28, p. 132.

WITMER (F. P.). — **Cross method applied to secondary stresses.** (900 words & fig.)

1932 — 313 .62 & 69

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1932 — 385. (09 .1 (.42)

Great Western Ry. Mag., January, p. 10.

The **past year's work in the principal departments.** (14 500 words & fig.)

1932 — 625 .247 (.42)

Great Western Ry. Mag., January, p. 69.

The **manufacture and maintenance of wagon sheets.** (850 words & fig.)

Indian Railway Gazette. (Calcutta.)

1932 — 625 .214

Indian Railway Gazette, January, p. 15.

HYDE (P. A.). — **Roller bearings for rolling stock.** (2 600 words.)

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1932 — 656 .212.5

Journal Institute of Transport, February, p. 165.

MAULDIN (H. H.). — **Mechanised marshalling yards** : their development and effect on operating. (15 000 words & fig.)

1932 — 656 .1

Journal, Institute of Transport, February, p. 187.

MARSTON (E. C.). — The **conveyance of abnormal traffic by road.** (2 000 words.)

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1931 — 625 .14 (0

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LAWSON (F.). — **Permanent way work** and its relationship to certain aspects of the industrial and transport problem. (7 800 words.)

1931 — 625 .17

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McDOUGALL (M.). — Modern **maintenance of permanent way.** (8 300 words.)

1931 — 625 .144.4

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DUGAY (S.). — **Laying in points and crossings with steam crane.** (2 100 words & fig.)

1931 — 625 .17

Journal, Perm. Way Institut., December, p. 311.

WEST (J. F.). — **Nature v. maintenance.** (2 000 words.)

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1932 — 621 .134.1 (.42)

Loc. Ry. Carriage & Wagon Review, January 15, p. 3.

Rebuilt **4-4-2 type passenger locomotives fitted with boosters,** London & North Eastern Ry. (1 100 words & fig.)

1932 621 .132.5 (.675)
Loc. Ry. Carriage & Wagon Review, January 15, p. 6.
« Mikado » locomotive, Kivu Railway. (500 words & fig.)

1932 621 .335 (.42) & 621 .43 (.42)
Loc. Ry. Carriage & Wagon Review, January 15, p. 8.
New 250 h. p. oil-electric rail-car : Armstrong-Whitworth standard. (2 600 words & fig.)

1932 621 .131.2
Loc. Ry. Carriage & Wagon Review, January 15, p. 25.
PHILLIPSON (E. A.). — **Steam locomotive design : data and formulæ.** (1 900 words.) (To be continued.)

1932 621 .335 (0
Loc. Ry. Carriage & Wagon Review, January 15, p. 30.
Electric locomotive design : IV. — **The electric locomotive as a vehicle.** (1 100 words & fig.) (To be continued.)

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1932 625 .26 (.42)
London & North Eastern Ry. Mag., February, p. 58.
THOM (R. A.). — **Progressive repairs to carriages at** Dukinfield Works. (1 500 words & fig.)

Modern Transport. (London.)

1932 656 .1 (.42)
Modern Transport, No. 672, January 30, p. 3.
The **railways and road competition.** Interview with Minister of Transport. (1 600 words.)

1932 625 .176 & 656 .22
Modern Transport, No. 672, January 30, p. 4.
Loading and running gauges. Their effect on **speed.** (1 100 words.)

1932 621 .335 (.82) & 621 .43 (.82)
Modern Transport, No. 672, January 30, p. 5.
Diesel-electric traction for Rosario. (1 400 words & fig.)

1932 621 .335 (.42) & 621 .43 (.42)
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The **Railways of China.** British interests in state-owned undertakings. (2 200 words & fig.)

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Notable developments in **rail containers.** London Midland & Scottish Railway to undertake **furniture removal.** (1 000 words & fig.)

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Modern Transport, No. 674, February 13, p. 2.
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South station, Boston, again a modern **terminal**. (3 400 words & fig.)

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Shop **accounting** forces consolidated on the Illinois Central. (2 000 words & fig.)

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Chicago & North Western **platform operation** sets fast pace. (3 500 words & fig.)

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A useful **battery truck** for general railway purposes. (1 400 words & fig.)

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Two recent **widenings** near London. (1 800 words & fig.)

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Santa Fe bare only eight holes in erecting 980-ft. trestle. (1 500 words & fig.)

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Specialized or general work for bridge and building gangs? (2 200 words & fig.)

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Providing sanitary facilities for outlying points. (2 000 words & fig.)

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The Micheline pneumatic-tyred rail car on the London Midland & Scottish Railway. (1 200 words & fig.)

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FERRARIO (A.). — **A quale sistema affidare la** ccessione **delle tranvie a vapore** per il trasporto dei aggiatori (2 900 parole.)

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THESEIDER-DUPRE. — Le grandi linee aeree per il asporto **dell' energia elettrica.** (16 000 parole & fig.)

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ANKERSMIT (L. A. M.). — **Spoorweg Gouda-Alphen** d. **Rijn.** (8 400 woorden & fig.)

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12.336 — M. Weissenbruch Co., Ltd., Printer to the King, 49, rue du Poinçon, Brussels.

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(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress jointly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to lway Science », by L. WEISSENBRUCH, in the number for November, 1897, of the *Bulletin of the International Railway Congress,* .509).

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[016 .385. (05]

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BACQUEYRISSE (L.). — Les **moteurs compound en traction électrique** et la récupération d'énergie. (13 000 mots & fig.)

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1932 621 .4
Bull. de la Soc. des ing. civ. de France, procès-verbal de la séance du 12 février, p. 78.
GREBEL. — Etude directe de la combustion et du choc dans les **moteurs à explosion.** (4 000 mots.)

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1932 385 .113 (.44)
Bull. de l'Union intern. des ch. de fer, février, p. 41.
Les **chemins de fer exploités** par l'Etat français en 1930. (7 000 mots.)

1932 385 .113 (.438)
Bull. de l'Union intern. des ch. de fer, février, p. 52.
Les **Chemins de fer de l'Etat polonais** pendant les exercices 1928 à 1930. (5 800 mots.)

1932 656 .1 & 656 .2
Bull. de l'Union intern. des ch. de fer, février, p. 60.
Concurrence et coopération entre chemin de fer et automobile. (4 800 mots.)

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1932 343 .346 (.44)
Bull. des transp. intern. par ch. de fer, février, p. 134.
La **responsabilité,** en droit français, des administrations de chemins de fer en matière d'attentats commis sur des voyageurs par d'autres voyageurs. (3 600 mots.)

1932 385 .113 (.44)
Bull. des transp. intern. par ch. de fer, février, p. 157.
Les **résultats de l'exploitation** des cinq grandes Compagnies de chemins de fer en 1930. (5 300 mots.)

1932 313 .385 (.489)
Bull. des transp. intern. par ch. de fer, février, p. 176.
Statistique des chemins de fer danois pour l'exercice 1930-31. (1 100 mots.)

Chronique des transports. (Paris.)

1932 347 .762
Chronique des transports, n° 4, 25 février, p. 2.
BOULLE. — Pour le respect des **contrats.** (2 400 mots.)

Génie civil. (Paris.)

1932 621 .4
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GREBEL (A.). — La combustion et le choc dans les **moteurs à explosion.** Résultats d'expériences directes. (8 500 mots & fig.)

1932 669 .1
Génie Civil, n° 2585, 27 février, p. 223.
GANDILLON. — L'étude scientifique et le problème pratique de la **trempe des aciers.** (750 mots & fig.)

1932 624 .8 (.73)
Génie Civil, n° 2586, 5 mars, p. 233.
La **travée basculante** à double volée du pont d'Arlington, sur le Potomac, à Washington. (2 800 mots & fig.)

1932 62. (01 & 721 .1
Génie Civil, n° 2586, 5 mars, p. 236.
MASSOTTE (E.). — **Détermination des charges** des pieux engagés dans une assise de fondation soumise à une charge résultante excentrée. (1 500 mots & fig.)

1932 621 .335
Génie Civil, n° 2586, 5 mars, p. 247.
Couplages de récupération pour **locomotives électriques à courant continu.** (2 500 mots & fig.)

1932 669
Génie Civil n° 2586, 5 mars, p. 248.
PORTEVIN (A.) & BASTIEN (P.). — Facteurs principaux de la **coulabilité des métaux purs.** (800 mots & fig.)

1932 385. (09 (.66)
Génie Civil, n° 2587, 12 mars, p. 263.
CAMUT (G.). — **Le chemin de fer franco-éthiopien.** Ligne de Djibouti à Addis-Abéba. (4 500 mots & fig.)

1932 669 .1
Génie Civil, n° 2587, 12 mars, p. 273.
La protection du fer et de l'acier contre l'**oxydation,** au moyen de peintures anti-rouille. (1 100 mots & fig.)

La Science et la Vie. (Paris.)

1932 621 .13 & 621 .335
La Science et la Vie, mars, p. 177.
PARODI (H.). — La **locomotive électrique** évincera-t-elle la locomotive à la vapeur. (5 300 mots & fig.)

1932 669
La Science et la Vie, mars, p. 207.
DEVAUX (P.). — Quelques nouveaux traitements en **métallurgie.** (4 300 mots & fig.)

1932 621 .9
La Science et la Vie, mars, p. 245.
LENOUVEL (L.). — La **machine-outil automatique** a créé la fabrication en grande série : vitesse et précision. (6 500 mots & fig.)

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1932 621 .335 & 621 .43
Les Chemins de fer et les Tramways, février, p. 22.
SPIESS (E.). — **Automotrice Diesel-électrique** Armstrong-Sulzer. (5 500 mots & fig.)

1932 621 .133.5
Les Chemins de fer et les Tramways, février, p. 26.
Les **échappements Kylchap.** (750 mots & fig.)

1932 621 .114
Les Chemins de fer et les Tramways, février, p. 28.
BRILLIÉ (H.). — Les phénomènes de **viscosité** et le **graissage.** Etude des films élémentaires. (7 500 mots, planches et fig.)

1932 656 .21 (.44)
Les Chemins de fer et les Tramways, février, p. 37.
DUCHESNOY. — La **reconstruction de la gare** de Versailles-Chantiers. (4 000 mots.)

L'Industrie des voies ferrées et des transports automobiles. (Paris.)

1932 625 .62
L'Ind. des voies ferrées et des transp. autom., janvier, p. 162.
POUILLET. — Moyens à employer pour augmenter la **vitesse commerciale** des tramways, notamment sur les lignes suburbaines. Rapport présenté à la VI^e Assemblée Générale Technique, de l'Union des voies ferrées et des transports automobiles (Lille, 15-18 juin 1931). (9 000 mots & fig.)

1932 625 .233
L'Ind. des voies ferrées et des transp. autom., janvier, p. 171.
GALLOIS. — **Eclairage des voitures** de transports en commun (Etude de l'éclairement). Rapport présenté à la VI^e Assemblée Générale Technique de l'Union des voies ferrées et des transports automobiles (Lille, 15-18 juin 1931). (8 800 mots, planches & fig.)

1932 621 .43
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AUDOUIN. — Emploi des **moteurs Diesel** sur les véhicules de transports automobiles. Rapport présenté à la VI^e Assemblée Générale Technique de l'Union des voies ferrées et des transports automobiles (Lille, 15-18 juin 1931). (5 600 mots & fig.)

1932 621 .4
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COMMARTIN. — Emploi des **moteurs à huile lourde** sur les V. F. I. L. Rapport présenté à la VI^e Assemblée Générale Technique de l'Union des voies ferrées et des transports automobiles. (Lille, 15-18 juin 1931). (4 700 mots.)

1932 621 .335
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JEANCARD (L.). — Communication sur les résultats obtenus par les **automotrices électriques à accumulateurs.** Rapport présenté à la VI^e Assemblée Générale Technique de l'Union des voies ferrées et des transports automobiles (Lille, 15-18 juin 1931). (1 700 mots & fig.)

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1932 624 .32 (.44)
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OUDOTTE. — Note sur les **travaux de consolidation du viaduc** du Grand Echaud. (Ligne de Longeray à Divonne.) (7 500 mots & fig.)

1932 621 .135.3 (.44) & 625 .213 (.44)
Revue Générale des chemins de fer, février, p. 112.
KOENIGER. — Note sur la **réparation** et la confection des **ressorts à lames** aux Chemins de fer d'Alsace et de Lorraine, à Bischheim. (3 400 mots & fig.)

1932 385. (09.3 (.54)
Revue Générale des chemins de fer, février, p. 120.
LAVIALLE d'ANGLARDS (H.). — La question des **chemins de fer** en Mandchourie. (6 000 mots & carte.)

1932 313 .385 (.44)
Revue Générale des chemins de fer, février, p. 129.
Résultats obtenus en 1930 sur le réseau des Chemins de fer de l'Etat en France, d'après les comptes d'Administration publiés pour ladite année. (Tableaux.)

1932 **651 (.42)**
Revue Générale des chemins de fer, mars, p. 183.
DUGAS. — Note sur l'emploi des **machines comptables** au Magasin général de Saint-Pierre-des-Corps. (4 500 mots & fig.)

1932 **625 .251**
Revue Générale des chemins de fer, mars, p. 192.
LIMON (F.). — **Porte-crushers omnibus** pour la mesure, en stationnement, des pressions effectives exercées aux sabots de freins du matériel roulant des chemins de fer. (4 500 mots & fig.)

1932 **656 .212.5**
Revue Générale des chemins de fer, mars, p. 201.
BUZENET & BOYSSOU. — Emploi de la **fiche de débranchement** pour le triage des wagons à la gravité. (5 800 mots & fig.)

1932 **385 .113 (.493)**
Revue Générale des chemins de fer, mars, p. 211.
Résultats du quatrième exercice (1930) de la Société Nationale des Chemins de fer belges. (7 400 mots & fig.)

1932 **621 .43 & 669**
Revue Générale des chemins de fer, mars, p. 230.
L'emploi de **l'aluminium** dans les automotrices. (1 400 mots.)

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1932 **625 .13**
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TOURNAY (Ch.). — L'emploi d'un bouclier pour le **percement d'un petit tunnel** fait réaliser une économie de 30 %. (2 200 mots.)

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1932 **621 .335 (.494)**
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ZEHNDER - SPOERRY (R.). — **Locomotives** B_0-B_0-B_0 pour le chemin de fer Montreux-Oberland bernois. (2 200 mots & fig.)

1932 **656 .254**
Revue univer. des transp. et des communications, janvier, p. 12.
Dispositif de **commande automatique des trains** pour empêcher le franchissement des signaux à l'arrêt, système Kofler. (1 100 mots & fig.)

In German.

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1932 **313 .385 (.3)**
Archiv für Eisenbahnwesen, Heft 1, Januar-Februar, S. 1.
Die **Eisenbahnen** der Erde im Jahr 1929. (2 200 Wörter.)

1932 **347 .763.4**
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von LAMBSDORF (Graf). — Die **Haftpflicht der Eisenbahn** nach deutschem und ausländischem Recht. (10 200 Wörter.)

1932 **656 (.42)**
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GRETSCH (R.). — Die **einheitliche Verkehrsregelung** in England. (10 400 Wörter.) (Schluss folgt.)

1932 **385 .1 (.73)**
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MERKERT (E.). — Die gefährdete **Lage der amerikanischen Eisenbahnen.** (6 600 Wörter, 13 Tafeln & Abb.) (Fortsetzung folgt.)

1932 **313 .385 (.43)**
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1932 **313 .385 (.42)**
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Die **Eisenbahnen** Grossbritanniens 1929. (2 400 Wörter.)

1932 **385 .1 (.73)**
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Die **Eisenbahnen** der Vereinigten Staaten von Amerika in den Jahren 1928 und 1929. (5 600 Wörter.)

1932 **385 .113 (.47)**
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WEHDE-TEXTOR. — Die **russischen Eisenbahnen** im Wirtschaftsjahr 1928-1929. (6 500 Wörter.)

1932 **385 .113 (.51)**
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WEHDE-TEXTOR. — Die **chinesischen Eisenbahnen** im Jahr 1927. (1 400 Wörter.)

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Die **Fahrgeschwindigkeit** der deutschen Schnellzüge 1900 bis 1931. (1 000 Wörter.)

Die Lokomotive. (Wien.)

1932 **621 .132.1 (497.1)**
Die Lokomotive, Februar, S. 21.
Die neuen **Einheitslokomotiven** der Jugoslavischen Staatsbahnen. (2 800 Wörter & Abb.)

1932 621 .132.3 (.437)
Die Lokomotive, März, S. 41.
2 C 1 **Heissdampf-Schnellzugslokomotive** Reihe 386 der Tschechoslovakischen Staatsbahnen. (600 Wörter & Abb.)

1932 625 .174)
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Schneeschleudermaschinen. (1 000 Wörter & Abb.)

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1932 621 .33 (.439)
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von VEREBELY (L.). — Die **Elektrisierung** der Linie Budapest-Hegyeshalom. (8 500 Wörter & Abb.)

1932 621 .335
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PFLANZ (K.). — Über den mechanischen Aufbau von **elektrischen Lokomotiven** der Achsfolge B + B. (2 400 Wörter & Abb.)

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KÜHNEL (R.). — **Achsbrüche** von Eisenbahnfahrzeugen und ihre Ursachen. (13 500 Wörter, 10 Tabelle & Abb.) (Fortsetzung folgt.)

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1932 625 .142.2
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PIRATH (C.). — Die Verarbeitung der Kraftangriffe in **hölzernen Eisenbahnschwellen.** (7 900 Wörter & Abb.)

1932 621 .135.4 & 625 .215
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HEUMANN. — Die **Reibung zwischen Rad und Schiene** im Bogen. (2 800 Wörter & Abb.)

1932 621. 43 (.47)
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AMMAN (O.) & GRUENEWALDT (C. v.). — Versuche über die Wirkung von **Längskräften im Gleis.** (8 500 Wörter & Abb.)

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WEISS (L.). — Beiträge zum **Nalenz-Höfer-Verfahren.** (1 400 Wörter & Abb.)

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FUCHS. — Neuere **Triebwagen mit Verbrennungsmotoren.** (2 Seiten & Abb.)

1932 385 .113 (.43)
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Die **Deutsche Reichsbahn** im Jahre 1931. Vorläufiger Jahresrückblick. (3 Seiten.)

1932 656 .235.7 (.43)
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ENGEL. — **Eisenbahngütertarife** und Landwirtschaft. (6 1/2 Seiten.)

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STEUERNAGEL. — **Konjunkturforschung und Eisenbahn.** Aus einem Vortrag in der Universität Berlin am 13. Januar 1932 im Rahmen der Verwaltungs-Akademie über « Die Bedeutung der Statistik für die Deutsche Reichsbahngesellschaft. (6 Seiten & Diagr.)

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1932 656 .212.4 & 656 .254
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BRÜCKMANN. — Eine neuartige **Lautsprecheranlage** für Rangierbahnhöfe. (2 1/2 Seiten & Abb.)

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1932 385. (09.3 (.431)
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HUELSENKAMP. — 50 Jahre Berliner Stadtbahn (16 1/2 Seiten & Abb.)

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1932 621 .132.[illegible]
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MEINEKE (F.). — Massenausgleich und gekapselte Steuerung bei **Zwillingslokomotiven.** (800 Wörter & Abb.)

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WALGER (O.). — **Schmiertechnische Untersuchungen.** (4 300 Wörter & Abb.)

1932 621 .116
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SCHULTE (F.). — Neuere **Dampfkesselbauarten.** (8 500 Wörter & Abb.)

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ALTMANN (F. G.). — **Bauformen der Getriebe** bei neueren Getriebemotoren. (2 900 Wörter & Abb.)

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MOSER (M.). — Zur Normung des **Kerbschlagversuches.** (3 800 Wörter & Abb.)

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SACHSENBERG (E.) & OSENBERG (W.). — Neuere **Messverfahren für Werkzeugmaschinen.** (3 700 Wörter & Abb.)

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GÖHNER (O.). — Die Berechnung zylindrischer **Schraubenfedern.** (4 100 Wörter & Abb.)

1932 621 .116
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MARGUERRE (F.). — Hohe **Dampftemperaturen.** Einige Erfahrungen und Betrachtungen. (5 300 Wörter & Abb.)

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1932 343 .346 (.43)
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Überall **Ablaufberge.** (1 100 Wörter.)

1932 656 .234
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1932 656 .212.6
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1932 62. (01 & 669
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1932 62. (01
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Materials for services at high temperatures. (2 300 words & fig.)

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The **position of the oil locomotive.** (1 400 words.)

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1932 624 .62 (.944)
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1932 656 .212.9
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1932 621 .392 (.42)
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An **all-welded steel framed building.** (1 700 words & fig.)

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The **British Industries Fair at Birmingham.** (45 000 words & fig.)

1932 621 .13 (0
Engineering, No. 3449, February 19, p. 224.
The **engineering outlook.** — VIII. — The **locomotive industry.** (5 900 words, 2 tables & fig.)

1932 669 .1
Engineering, No. 3449, February 19, p. 229.
BRAMLEY (A.). — **The loss of carbon from iron and steel** when heated in decarburising gases. (2 200 words, tables & fig.)

1932 621 .33
Engineering, No. 3449, February 19, p. 232.
TWINBERROW (J. D.). — The **mechanism of electric locomotives.** Discussion of paper read before The Institution of Mechanical Engineers North-Western Branch, Manchester. (3 300 words & fig.)

1932 621 .3
Engineering, No. 3450, February 26, p. 253.
Modern **power station practice.** (2 000 words.)

1932 62. (0
Engineering, No. 3450, February 26, p. 261.
BAILEY (R. W.) & ROBERTS (A. M.). — **Testing of materials for service in high-temperature steam plant.** (6 500 words, tables & fig.)

1932 621 .94
Engineering, No. 3450, February 26, p. 265.
Combination turret lathes with covered beds. (2 600 words, tables & fig.)

1932 621 .43 (.42)
Engineering, No. 3450, February 26, p. 268.
Pneumatic-tyred rail motor coach. (800 words.)

1932 62. (01 & 669
Engineering, No. 3451, March 4, p. 293.
BARR (W.) & BARDGETT (W. E.). — An accelerated test for the determination of the limiting creep stress of metals. (1 500 words, 2 tables & fig.)

1932 621 .335 (.42) & 621 .43 (.42)
Engineering, No. 3451, March 4, p. 299.
The Armstrong-Whitworth rail coach. (1 000 words.)

1932 62. 01
Engineering, No. 3452, March 11, p. 306.
BAILEY (R. W.) & ROBERTS (A. M.). — Testing of materials for service in high temperature steam plant. Paper presented at the Institution of Mechanical Engineers, North-Western Branch. (3 700 words & fig.)

1932 621 .33 (.54)
Engineering, No. 3452, March 11, p. 313.
WHITE (B. G.). — The electrification of the Madras suburban section of the South Indian Railway. (1 100 words.)

1932 669 (06 (.42)
Engineering, No. 3452, March 11, p. 321.
The Institute of Metals, 24th annual meeting. (4 000 words.)

1932 62. 01 & 669
Engineering, No. 3452, March 11, p. 329.
NEWTON FRIEND (J.). — The relative corrodibilities of ferrous and non-ferrous metals and alloys. (2 200 words, tables & fig.)

Engineering News-Record. (New York.)

1932 624 .63 (.73)
Engineering News-Record, No. 6, February 11, p. 202.
Double-deck viaduct built over Cincinnati Terminal. (4 200 words & fig.)

1932 725 .33 (.73)
Engineering News-Record, No. 8, February 25, p. 279.
The radial-cone-bottom tank for elevated water storage. (2 000 words & fig.)

1932 621 .39 (.73) & 725 .33 (.73)
Engineering News-Record, No. 8, February 25, p. 281.
RUPARD (H.). — Electrical devices control level of new 1.5 million gallons tank. (1 200 words & fig.)

1932 624 .8 (.73)
Engineering News-Record, No. 9, March 3, p. 318.
FOULDS (R. S.). — Erecting 3 800-ton bascules in the Arlington bridge. (1 700 words & fig.)

1932 621 .43 (.73)
Engineering News-Record, No. 9, March 3, p. 326.
New lightweight car built for fast railway service. (900 words & fig.)

Indian Railway Gazette. (Calcutta.)

1932 624 .32 (.54)
Indian Railway Gazette, February, p. 33.
Viceroy opens the « Willingdon Bridge », Calcutta Chord Railway. (3 900 words & fig.)

1932 625 .2 (.436)
Indian Railway Gazette, February, p. 45.
STRAUSS (F.). — New rolling-stock on the Austrian Federal Railways. (1 600 words & fig.)

Locomotive, Railway Carriage & Wagon Review. (London.)

1932 621 .132.6 (.42)
Loc. Ry. Carr. & Wagon Review, February 15, p. 39.
New 2-6-4 goods tank locomotives, class « W », Southern Ry. (300 words & fig.)

1932 625 .616 (.54)
Loc. Ry. Carr. & Wagon Review, February 15, p. 41.
4-6-2 type locomotives, Gwalior Light Rys. (800 words & fig.)

1932 621 .335 (.593) & 621 .43 (.593)
Loc. Ry. Carr. & Wagon Review, February 15, p. 42.
Diesel-electric locomotives for the Siamese State Rys. (1 200 words & fig.)

1932 621 .132.8 (.65)
Loc. Ry. Carr. & Wagon Review, February 15, p. 44.
Beyer-Garratt locomotives for the Blidah-Djelfa Ry., Algeria. (1 000 words & fig.)

1932 625 .251
Loc. Ry. Carr. & Wagon Review, February 15, p. 49.
The SAB type D double-acting automatic slack adjuster. (2 000 words & fig.)

1932 621 .131
Loc. Ry. Carr. & Wagon Review, February 15, p. 53.
PHILLIPSON (E. A.). — Steam locomotive design : data and formulæ. (900 words & tables.)

1932 621 .132.3 (.71)
Loc. Ry. Carr. & Wagon Review, February 15, p. 55.
Canadian National Rys. Mountain type locomotives. (400 words & fig.)

1932 **621 .132.1 (.460)**
Loc. Ry. Carr. & Wagon Review, February 15, p. 56.
WRIGHT (J. K. A.). — **Recent locomotives built** by the « Sociedad Española de Construcciones Babcok & Wilcox ». (1 900 words & fig.)

1932 **621 .133.7 (.83)**
Loc. Ry. Carr. & Wagon Review, February 15, p. 67.
Treatment of feed water for locomotive boilers on the Nitrate Rys., Chile. (1 100 words.)

1932 **621 .335**
Loc. Ry. Carr. & Wagon Review, February 15, p. 69.
Electric locomotive design. — IV. (800 words & fig.)

1932 **621 .392 (.73) & 625 .246 (.73)**
Loc. Ry. Carr. & Wagon Review, February 15, p. 72.
Welded freight cars, built by the Pullmann Car Co. (400 words & fig.)

London & North Eastern Railway Magazine. (London.)

1932 **621 .134.1 (.42)**
London & North Eastern Ry. Mag., March, p. 121.
Rebuilt express locomotives with boosters. (1 100 words & fig.)

Mechanical Engineering. (New York.)

1932 **536**
Mechanical Engineering, March, p. 190.
KING (W. J.). — **The basic laws and data of heat transmission.** (4 200 words & fig.)

1932 **536**
Mechanical Engineering, March, p. 195.
KEENAN (J. H.). — **A steam chart for second-law analysis.** (7 400 words & fig.)

Modern Transport. (London.)

1932 **621 .138.2 & 621 .43**
Modern Transport, No. 675, February 20, p. 2.
Experiments with **rail cars.** (1 200 words.)

1932 **385 .1 & 657**
Modern Transport, No. 675, February 20, p. 3.
DICKINSON (Sir A. L.). — Railway accountancy. Problem of **charging to capital and revenue.** (2 400 words.)

1932 **656 .211 (.68) & 725 .31 (.68)**
Modern Transport, No. 675, February 20, p. 4.
Rebuilding of Johannesburg **station.** (3 400 words.)

1932 **656 .213 (.41)**
Modern Transport, No. 675, February 20, p. 7.
Industrial traffic management. No. 19. — Scottish railway **dock charges.** (1 700 words.)

1932 **656 .212 (.42)**
Modern Transport, No. 676, February 27, p. 3.
Notable improvement in **goods terminal facilities.** (5 400 words & fig.)

1932 **656 .255 (.42) & 656 .259 (.42)**
Modern Transport. No. 676, February 27, p. 7.
Signalling of single lines. (2 000 words & fig.)

1932 **656 .211.7**
Modern Transport, No. 676, February 27, p. 8.
HARDY (A. C.). — The cross-channel **train ferry.** Considerations of **design.** (2 000 words & fig.)

1932 **621 .33**
Modern Transport, No. 676, February 27, p. 11.
DAWSON (Sir P.). — **Economics of railway electrification.** (2 400 words.)

1932 **621 .338**
Modern Transport, No. 676, February 27, p. 13.
New rolling stock for London Underground Railways. (2 200 words & fig.)

1932 **669 .1**
Modern Transport, No. 676, February 27, p. 18.
Developments in **alloy and other steels.** (1 900 words & fig.)

1932 **621 .335**
Modern Transport. No. 677, March 5, p. 3.
Electric locomotives for mixed traffic. (2 900 words & fig.)

1932 **656 .262 (.42)**
Modern Transport, No. 677, March 5, p. 5.
Railway hotels and catering. — A successful ancillary business. (1 600 words & tables.)

1932 **656 .2**
Modern Transport, No. 677, March 5, p. 13.
Industrial traffic management No. 20. — **Proceedings of the Railway Rates Tribunal.** (1 900 words.)

1932 **621 .335 (.41)**
Modern Transport, No. 678, March 12, p. 3.
Battery-driven passenger trains on Great Southern Railways, Ireland. (2 300 words & fig.)

1932 **621 .33**
Modern Transport, No. 678, March 12, p. 4.
Railway electrification. — Effect on train working. (2 700 words.)

1932 **621 .335 & 621 .4**
Modern Transport, No. 678, March 12, p. 9.
CHORLTON (A. E. L.). — **Oil-electric traction.** No. 1. Some outstanding **characteristics.** (2 200 words.)

1932 **656 .1 & 656 .**
Modern Transport. No. 678, March 12, p. 10.
Road users' reply to railway manifesto. (2 700 words.)

1932 656 .1 & 656 .2
Modern Transport, No. 678, March 12, p. 11.
Road hauliers and the railways. (2 300 words & 1 table.)

1932 656 .1 (.42) & 656 .2 (.42)
Modern Transport, No. 678, March 12, p. 16.
Problem of **rail and road competition.** (2 200 words.)

1932 656 .1 (.42) & 656 .2 (.42)
Modern Transport, No. 678, March 12, p. 17.
SHEPHARD (W. R.). — Closer **relationship of rail and road.** (2 000 words.)

Proceedings, Institution of Civil Engineers. (London.)

1929-1930 624 .2
Proceed., Institut. of Civil Eng., Vol. 229, Part I, p. 33.
COKER (E. G.). — Some experimental methods and apparatus for **determining the stresses in bridges and framed structures.** (15 000 words & fig.)

1932 621 .43
Proceed., Institut. of Civil Eng., Vol. 229, Part I, p. 197.
CHORLTON (E. L.). — **Railway traction by oil-engines.** (24 000 words, tables & fig.)

Proceedings, Institution of Mechanical Engineers. (London.)

1931 621 .131.3
Proceed., Institut. of Mech. Engineers, July, p. 23.
GRESLEY (H. N.). — **Locomotive experimental stations.** (10 000 words & fig.)

Railway Age. (New York.)

1932 625 .142.2 (.73) & 691 (.73)
Railway Age, No. 6, February 6, p. 235.
Treating timber for railway uses. (8 300 words & fig.)

1932 656 .221
Railway Age, No. 6, February 6, p. 240.
TIETJENS (O. G.) & RIPLEY (K. C.). — A study **of air resistance at high speeds.** (3 300 words & fig.)

1932 621 .33 (06 (.73)
Railway Age, No. 6, February 6, p. 246.
Electrification of steam railroads. (1 200 words, 2 tables & fig.)

1932 385 .3 (.73) & 656 .23 (.73)
Railway Age, No. 6, February 6, p. 248.
LANE (H. F.). — Roads assent to new Section 15a (rates). (7 000 words.)

1932 656 .1 (.73)
Railway Age, No. 6, February 6, p. 254.
BECK (C. V.). — Trucks making **heavy inroads into short haul coal traffic.** (4 200 words & 4 tables.)

1932 385 .3 (.73) & 656 .231 (.73)
Railway Age, No. 7, February 13, p. 269.
The proposed rule of **rate-making.** (4 200 words.)

1932 621 .135.2 (.73)
Railway Age, No. 7, February 13, p. 274.
Timken locomotive completes first 100 000 miles of service. (8 000 words, 5 tables & fig.)

1932 625 .258 (.73) & 656 .212.5 (.73)
Railway Age, No. 7, February 13, p. 283.
SCHRIJVER (H. F.). — Ohio Central **replaces yard only three years old.** (3 800 words & fig.)

1932 625 .1 (.73)
Railway Age, No. 8, February 20, p. 315.
The Great Northern in California. (3 600 words & fig.)

1932 656 .255 (.73)
Railway Age, No. 8, February 20, p. 320.
Centralized traffic control installed on the Baltimore & Ohio. (2 800 words & fig.)

1932 621 .138.2 (.73)
Railway Age, No. 8, February 20, p. 324.
WOODBRIDGE (H. C.). — **Railway fuel.** (3 900 words.)

1932 656 .1 (.73)
Railway Age, No. 8, February 20, p. 327.
PELLEY (J. J.). — **How regulate motor carriers?** (3 300 words.)

1932 625 .1 (.73)
Railway Age, No. 9, February 27, p. 352.
PHILLIPS (T. L.). — The Western Pacific **builds 112-mile line** in 15 months. (2 900 words & fig.)

1932 625 .213 (.73)
Railway Age, No. 9, February 27, p. 357.
BARROWS (D. S.). — **Synchronous truck spring movement** produces destructive forces. (4 600 words & fig.)

1932 656 .1 (.73)
Railway Age, No. 9, February 27, p. 367.
Train-connection motor coaches prove worth. (1 600 words & fig.)

1932 656 .261 (.73)
Railway Age, No. 9, February 27, p. 369.
CAREY (F. J.). — Seven years of **trucking.** (4 200 words & fig.)

Railway Engineer. (London.)

1932 **621 .335 & 621 .43**
Railway Engineer, March, p. 83.
Electric transmission for railcars. (800 words.)

1932 **625 .143.2 (.73) & 625 .143.3 (.73)**
Railway Engineer, March, p. 87.
Heat-treating of rail-ends. (1 250 words.)

1932 **621 .332 (.460)**
Railway Engineer, March, p. 88.
PONTECORVO (L.). — The autocompensated **catenary system of contact wire.** (2 200 words & fig.)

1932 **621 .334 (.42)**
Railway Engineer, March, p. 91.
Mobile trucks for railway use. — III. (1 400 words & fig.)

1932 **621 .138.5 (.42)**
Railway Engineer, March, p. 93.
Reorganisation of Derby **Locomotive Works,** London Midland & Scottish Ry. (4 300 words & fig.)

1932 **621 .43 (.42)**
Railway Engineer, March, p. 101.
Pneumatic-tyred railcar trials on the London Midland & Scottish Ry. (700 words & fig.)

1932 **621 .43 (.54)**
Railway Engineer, March, p. 104.
Petrol-driven rail motor car, Kalka-Simla Railway. (600 words & fig.)

1932 **621 .134.1 (.42)**
Railway Engineer, March, p. 106.
Development of the **locomotive booster** on the London & North Eastern Ry. (3 200 words & fig.)

1932 **621 .131.2**
Railway Engineer, March, p. 110.
The « 3-30 ». — **The next-locomotive (?).** — II. (2 500 words & fig.)

1932 **621 .335 & 621 .43**
Railway Engineer, March, p. 112.
MIALL (S.). — **Electrical drive for railcars** with **internal-combustion engines.** (3 900 words & fig.)

1932 **625 .143.5**
Railway Engineer, March, p. 117.
The **galvanising of screw spikes** for railway chairs. (1 700 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1932 **625 .174 (.73)**
Railway Engineering and Maintenance, February, p. 94.
Intense cold and heavy snow make winters severe in Maine. (2 600 words & fig.)

1932 **625 .144.4 (.73)**
Railway Engineering and Maintenance, February, p. 97.
The **maintenance of ballast-deck trestles.** (4 200 words & fig.)

1932 **625 .153 (.73)**
Railway Engineering and Maintenance, February, p. 101.
Track layout made to measure. (2 000 words & fig.)

1932 **625 .142.2 (.73) & 691 (.73)**
Railway Engineering and Maintenance, February, p. 109.
Service records prove **worth of treated timber.** (2 600 words & fig.)

1932 **625 .142.2 (.73) & 691 (.73)**
Railway Engineering and Maintenance, February, p. 111.
McBRIDE (J. S.). — Thirty-two years **experience with treated ties.** (1 400 words & fig.)

1932 **625 .144.4 (.73)**
Railway Engineering and Maintenance, March, p. 174.
What is the demand for **labor-saving equipment.** The volume of purchases to date. The degree of saturation. The needs not yet met. (5 400 words & fig.)

1932 **625 .144.4 (.73) & 625 .17 (.73)**
Railway Engineering and Maintenance, March, p. 179.
One use or many ? Should **general-purpose appliances** be prefered to **machines designed to perform one task** with maximum efficiency. (3 000 words & fig.)

1932 **625 .144.4 (.73) & 625 .17 (.73)**
Railway Engineering and Maintenance, March, p. 182.
Lehigh Valley cutting **(Maintenance of Way) expenses** in half, in five years' time. (7 300 words & fig.)

1932 **625 .144.4 (.73) & 625 .17 (.73)**
Railway Engineering and Maintenance, March, p. 189.
What of the organization. — Does the use of **power equipment** point to the need for a **redistribution of forces** for the performance of maintenance of way work. (3 600 words & fig.)

1932 **624. (0 (.73)**
Railway Engineering and Maintenance, March, p. 192.
Modernizing **bridge maintenance methods.** (3 300 words & fig.)

Railway Gazette. (London.)

1932 **621 .132.3 (.44)**
Railway Gazette, No. 8, February 19, p. 245.
Super-Pacific locomotives, Chemin de fer du Nord, France. (1 300 words & fig.)

1932 **621 .33 (.41)**
Railway Gazette, No. 8, February 19, p. 246.
COPPOCK (C.). — The Drumm **battery** and Irish **railway electrification.** (2 700 words.)

1932 **625 .153 (.42)**
Railway Gazette, No. 8, February 19, p. 248.
Complicated **relaying** at Newcastle-upon-Tyne. L. N. E .R. (1400 words & fig.)

1932 625 .26 (.42)
ilway Gazette, No. 8, February 19, p. 251.
Underground Railways' rolling stock repair methods. 000 words & fig.)

1932 621 .335 (.42) & 621 .43 (.42)
ilway Gazette, No. 8, February 19, p. 255.
Trials of Diesel-electric railcars, L. N. E. R. (700 rds & fig.)

1932 385 .3 (.42) & 656 .1 (.42)
ilway Gazette, No. 9, February 26, p. 275.
Fair play for the railways. (2 600 words.)

1932 656 .211 (.42)
ilway Gazette, No. 9, February 26, p. 278.
Improvements at Bournemouth, Southern Railway. 800 words & fig.)

1932 621 .43 (.494)
ilway Gazette, No. 9, February 26, p. 284.
A 300-B. H. P. Diesel railcar of novel design. (1 500 rds & fig.)

1932 621 .335 (.51) & 621 .43 (.51)
ilway Gazette, No. 9, February 26, p. 287.
GERCKE (M.). — Diesel-electric main-line locomo-es, South Manchurian Railway. (1 600 words, 3 ta-s & fig.)

1932 621 .43
ilway Gazette, No. 9, February 26, p. 290.
MIALL (S.). — Transmissions for Diesel locomotives d railcars. — II. (2 300 words & fig.)

1932 621 .43 (.485)
ilway Gazette, No. 9, February 26, p. 293.
Railcar trials in Sweden. (600 words & fig.)

1932 656 .259 (.42)
ilway Gazette, No. 10, March 4, p. 331.
Protection of trolleys on single line. (1 500 words & .)

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932 625 .175 (.42)
ilway Gazette, No. 10, March 4, p. 332.
ower trolleys for permanent way maintenance. (600 rds & fig.)

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932 621 .392 (.42) & 624 (.42)
lway Gazette, No. 10, March 4, p. 333.
Bridge reconstruction by electric welding, L. N. E. R. 000 words.)

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932 385. (091 (.495)
lway Gazette, No. 10, March 4, p. 334.
LEONDOPOULOS (B. L.). — The Hellenic State lways. (2 500 words, tables & fig.)

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932 621 .335 (.41)
lway Gazette, No. 11, March 11, p. 382.
Drumm battery electric traction, G. S. R. (1 400 rds & fig.)

1932 625 .143.4 (.73)
Railway Gazette, No. 11, March 11, p. 385.
Head-free joints and rails. (1 200 words & fig.)

Railway Mechanical Engineer. (New York.)

1932 621 .133.3 (.73) & 621 .138.5 (.73)
Railway Mechanical Engineer, February, p. 51.
Chicago, Milwaukee, St. Paul & Pacific progressive flue repair shop. (2 200 words & fig.)

1932 625 .214 (.73)
Railway Mechanical Engineer, February, p. 55.
Railroad-car lubrication tests. (1 300 words & fig.)

1932 385 .586 (.73) & 625 .253 (.73)
Railway Mechanical Engineer, February, p. 59.
DRENNAN (C. M.). — Teaching air brakes. (1 300 words & fig.)

1932 656 .221
Railway Mechanical Engineer, February, p. 61.
TIETJENS (O. G.) & RIPLEY (K. C.). — Air resistance of high speed trains. (1 500 words & fig.)

Railway Signaling. (Chicago.)

1932 656 .258 (.73) & 656 .259 (.73)
Railway Signaling, February, p. 33.
Automatic interlocking replaces mechanical plant. (1 500 words & fig.)

1932 656 .255 (.73)
Railway Signaling, February, p. 36.
Centralized traffic control installed on the Baltimore & Ohio. (4 400 words & fig.)

1932 385 .3 (.73) & 656 .254 (.73)
Railway Signaling, February, p. 42.
Interstate Commerce Commission permits Great Northern to discontinue train control. (1 300 words & fig.)

1932 625 .162 (.73) & 656 .254 (.73)
Railway Signaling, February, p. 43.
Flashing-light crossing signals save $ 3 000 annually. (2 000 words & fig.)

1932 656 .258 (.73)
Railway Signaling, February, p. 47.
MOLIS (B. W.). — Utah permits installation of automatic interlocking. (1 800 words & fig.)

1932 656 .255 (.73)
Railway Signaling, February, p. 49.
KELLENBERGER (K. E.). — Centralized traffic control. (2 000 words & fig.)

1932 625 .162 (.73) & 656 .254 (.73)
Railway Signaling, February, p. 51.
New York State amends crossing signal regulations. (1 600 words.)

Transit Journal. (New York.)

1932 621 .43
Transit Journal, March, p. 113.
Light-weight rail car with pneumatic tires. (1 700 words & fig.)

1932 656. 257 (.73)
Transit Journal, March, p. 127.
Interlocking plant controls trains at Illinois Central suburban terminal. (700 words & fig.)

1932 625 .614 (.73)
Transit Journal, March, p. 132.
Track joint construction methods. (1 700 words & fig.)

University of Illinois Bulletin. (Urbana.)

1931 693
University of Illinois Bulletin, No. 17, October 27, p. 1.
RICHART (F. E.) & JENSEN (V. P.). — **Tests of plain and reinforced concrete** made with Haydite aggregates. (22 400 words & fig.)

In Spanish.

Ferrocarriles y Tranvias. (Madrid.)

1932 625 .1 (.460)
Ferrocarriles y Tranvias, enero, p. 4.
ESCUDERO AREVALO (M.). — El **ferrocarril** directo de Madrid a Burgos. (2 700 palabras & fig.)

1932 621 .43
Ferrocarriles y Tranvias, enero, p. 12.
BASTOS (M.). — **Automotrices y locomotoras** Diesel. (2 100 palabras & fig.)

Revista de Ingenieria Industrial. (Madrid.)

1932 621 .33
Revista de Ingenieria Industrial, enero, p. 1.
SIEGRIST SPINEDY (E.). — Aplicación de la distribución trifilar a la **tracción eléctrica.** (3 500 palabras & fig.)

1932 656 .231 (.460)
Revista de Ingenieria Industrial, febrero, p. 42.
RAHOLA (S.). — La **tarificacion** en los ferrocarriles españoles. (2 000 palabras & fig.)

Revista de Obras Públicas. (Madrid.)

1932 385 .1 (.460)
Revista de Obras Públicas; nº 5, 10 de marzo, p. 101; nº 6, 15 de marzo, p. 125.
MACHIMBARRENA (V.). — El **ferrocarril** de Zamora a Orense y Coruña. (10 700 palabras & fig.)

1932 691
Revista de Obras Públicas, nº 6, 15 de marzo, p. 129.
RIOS (R.). — La **dosificación de los hormigones.** (3 900 palabras & fig.)

In Italian.

Rivista tecnica delle ferrovie italiane (Roma).

1932 625 .235 & 625 .246
Rivista tecnica delle ferrovie italiane, 15 febbraio, p. 65.
PAGNINI (D.). — Le **leghe leggere** di alluminio nella costruzione del materiale rotabile delle grandi reti. (10 200 parole & fig.)

1932 621 .332
Rivista tecnica delle ferrovie italiane, 15 febbraio, p. 106.
THESEIDER-DUPRE. — Le grandi **linee aeree** per il trasporto dell' energia elettrica. (5 200 parole & fig.)

In Dutch.

De Ingenieur. (Den Haag.)

1932 621 .133.1 (.42)
De Ingenieur, Nr 9, 26 Februari, p. 13.
VAN LIER (R. J.). — De **Britsche Standaard Voorschriften** voor het monstertrekken en de analyse van steenkolen. (5 000 woorden, 3 tafereelen & fig.)

Spoor- en Tramwegen. (Utrecht.)

1932 656 .1 (.436)
Spoor- en Tramwegen, Nr 5, 1 Maart, p. 106.
RAINER REINÖHL. — Het oostenrijksche **kraftfahrliniengesetz.** (2 000 woorden.)

1932 621 .43
Spoor- en Tramwegen, Nr 5, 1 Maart, p. 109.
SIMON-THOMAS (W.). — **De automotrice en haar evolutie.** (3 800 woorden & fig.)

1932 385. (074 (.492)
Spoor- en Tramwegen, Nr 5, 1 Maart, p. 113.
BOTERENBROOD (J.). — De **bovenbouw** van den spoorweg en het **spoorwegmuseum.** (1 000 woorden & fig.)

1932 625. (72
Spoor- en Tramwegen, N 6, 8 Maart, p. 132.
DRIESSEN (Ch. H. J.). — **Onderzoek naar de ligging van het spoor met behulp van een meetwagen.** (3 500 woorden & fig.) (Wordt vervolgd.)

In Czech.

(91.886)

Zprávy železničních inženýrů. (Praha.)

1932 — 625 .113 = 91 .886

právy zeleznicnich inzenyru, No. 1, p. 2; No. 2, p. 23.

PELINKA. — **The lemniscate as a transition curve.** 250 words & fig.)

1932 — 656 .222.1 (.437) = 91 .886

právy zeleznicnich inzenyru, No. 1, p. 6.

VAVERKA. — Remarks about the possibility of in-eased **train speeds** decided upon by the Czechoslo-kian State Railways. (6 050 words.)

1932 — 621 .132.3 (.437) = 91 .886

právy zeleznicnich inzenyru, No. 2, p. 26.

KOREF. — The 387-0 class **locomotives for fast trains** the Czechoslovakian State Railways. A study. (5 500 ords & diagr.)

1932 — 656 .222.1 (.437) = 91 .886

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WUNDENBERG. — **Mechanische Schwellenbearbeitungsanlage.** (1 300 Wörter & Abb.)

1932 621 .134.3 (.494)
Organ für die Fortschritte des Eisenbahnwesens, Heft 8, 15. April, S. 166.
Versuchsergebnisse der **Hochdrucklokomotive** der Lokomotivfabrik Winterthur. (1 500 Wörter & Abb.)

Zeitung des Vereins deutscher Eisenbahnverwaltungen. (Berlin.)

1932 656 .225
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 12, 24 März, S. 265.
BURGER. — Der **Sammelladungsverkehr.** (2 800 Wörter.)

1932 385
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 12, 24. März, S. 272.
HOFFMANN (A.). — **Verkehrswerbung.** (2 800 Wörter.)

1932 621 .33
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 13, 31. März, S. 291.
SCHMITT (H.). — Über die Entwicklung der verschiedenen **Bahnstromsysteme.** (1 800 Wörter & 2 Tafeln.)

1932 656 .1
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 14, 7. April, S. 309.
SPIES (R.). — Kraftfahrzeuganhänger, Rollböcke und Radwechselvorrichtungen zur **Beförderung von Eisenbahnwagen auf Strassen.** (3 700 Wörter & Abb.)

1932 656
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 15, 14. April, S. 335.
JANECKE (L.). — **Verkehrsprobleme** der Gegenwart. (3 200 Wörter, 5 Tafeln & Abb.)

1932 656 .212.4
Zeitung des Vereins deutsch. Eisenbahnverw., Nr. 16, 21. April, S. 357.
WERNER (P.). — Hilfsmittel der **Rangiertechnik.** (2 100 Wörter & Abb.)

Zeitschrift des Vereines Deutscher Ingenieure. (Berlin.)

1932 625 .245
Zeitsch. des Ver. deutsch. Ing., Nr. 13, 26. März, S. 311.
BIECK (H.). — Normung der **Kesselwagen.** (4 700 Wörter, 8 Tafeln & Abb.)

1932 669 .1
Zeitsch. des Ver. deutsch. Ing., Nr. 13, 26. März, S. 317.
MEYER (O.) & EILENDER (W.). — **Die Härtung legierter Stähle durch Stickstoff.** (4 100 Wörter & Abb.)

1932 621 .132.8
Zeitsch. des Ver. deutsch. Ing., Nr. 13, 26. März, S. 323.
METZELTIN (E.). — Die **Entwicklung des Dampflokomotivbaues.** (1 800 Wörter & Abb.)

1932 621 .132.8
Zeitsch. des Ver. deutsch. Ing., Nr. 16, 16. April, S. 397.
LEONHARDT (R.). — Zur Entwicklung des **Schienenomnibusses.** (1 800 Wörter, 1 Tafel & Abb.)

In English.

Engineer. (London.)

1932 .624 .63 (.944)
Engineer, No. 3976, March 25, p. 330; No. 3977, April 1, p. 359; No. 3978, April 8, p. 384; No. 3979, April 15, p. 413.
Sydney Harbour bridge — Approach spans. (12 000 words & fig.)

1932 669 (06 (.42)
Engineer, No. 3976, March 25, p. 332.
Selenium as a protective coating. (4 700 words.)

1932 621 .94 (.42)
Engineer, No. 3976, March 25, p. 347.
Railway carriage and wagon wheel turning plant. (1 400 words & fig.)

1932 669 .1
Engineer, No. 3976, March 25, p. 350; No. 3977, April 1, p. 372.
ROBINSON (F. E.) & NESBITT (C. T.). — The **machinability of steel** as indicated by its **macrostructure.** (5 400 words & fig.)

1932 621 .33 (.44)
Engineer. No. 3977, April 1, p. 369.
Railway electrification in France. (800 words.)

1932 621 .33 & 621 .43
ngineer, No. 3977, April 1, p. 370.
The position of the oil locomotive. (1 900 words.)

1932 656 .211.7 (.7)
ngineer, No. 3978, April 8, p. 388; No. 3979, April 15, p. 429.
TRATMAN (E. E. R.). — American **sea-going train-rry steamers.** (6 700 words & fig.)

1932 625 .1 (.42)
ngineer, No. 3978, April 8, p. 392.
L. N. E. Ry. — Romford widening. (1 200 words & g.)

1932 62. (01, 621 .392 & 665 .882
ngineer, No. 3978, April 8, p. 393.
STEPHEN (R. A.). — X-rays in the welding indus-y. 1 900 words & fig.)

Engineering. (London.)

1932 621 .31 (.73)
ngineering, No. 3453, March 18, p. 331.
The State Line **station** of the Chicago District **Elec-ic Generating** Corporation. (3 500 words & fig.)

1932 624 .63 (.944)
gineering, No. 3453, March 18, p. 334.
The **Sydney Harbour bridge.** (600 words & fig.)

1932 669 (06 (.42)
gineering, No. 3453, March 18, p. 334.
Interaction of **aluminium and water vapour.** (8 000 rds & fig.)

1932 621 .43
gineering, No. 3453, March 18, p. 348.
Oil **engine traction.** (2 200 words.)

1932 669 .1
gineering, No. 3454, March 25, p. 379.
ROBINSON (F. E.) & NESBITT (C. T.). — The chinability **of steel** as indicated by its macrostruc-re. (4 500 words & fig.)

1932 55 & 625 .13
gineering, No. 3456, April 8, p. 418.
DAVISON (Ch.). — **Earthquake motion in rail-y tunnels.** (700 words.)

1932 385 .1
gineering, No. 3456, April 8, p. 433.
The **railway situation.** (2 900 words.)

932 625 .122
gineering, No. 3456, April 8, p. 437.
3/4-cubic yard universal **excavator.** (1 800 words &)

932 625 .246
gineering, No. 3456, April 8, p. 441.
The **transportation of a 50 000 kw. alternator.** (800 rds & fig.)

1932 656 .212.8 (.73)
Engineering, No. 3457, April 15, p. 457.
« Krane Kar » **mobile crane.** (650 words & fig.)

Engineering News-Record. (New York.)

1932 691 (.73) & 721 .1 (.73)
Engineering News-Record, No. 10, March 10, p. 353.
Creosoted piles good as new after 13 to 21 years' use. (700 words.)

1932 624 .62 (.73)
Engineering News-Record, No. 10, March 10, p. 358.
Floor placed first in **erecting large steel arch.** (1 800 words & fig.)

1932 693 (06 (.73)
Engineering News-Record, No. 10, March 10, p. 369.
New research foreshadows changes in **concrete** art. (5 000 words & 2 tables).

1932 624 .51 (.73)
Engineering News-Record, No. 11, March 17, p. 386.
STEINMAN (D. B.) & GRONQUIST (C. H.). — Building first **long span bridge** in Maine. (3 500 words & fig.)

1932 625 .1 (.73)
Engineering News-Record, No. 12, March 24, p. 422.
New Pacific Coast **rail line** formed by 203-mile link. (2 800 words & fig.)

1932 624 .8 (.73)
Engineering News-Record, No. 12, March 24, p. 426.
Long pontoon forms **drawspan in railway bridge.** (1 000 words & fig.)

1932 625 .1 (.51)
Engineering News-Record, No. 12, March 24, p. 427.
SHAW (A. M.). — **Chinese railways continue construction** work. (1 500 words & fig.)

1932 624 .32 (.73)
Engineering News-Record, No. 12, March 24, p. 436.
DOLL (Th.). — Need for speed with economy governs Santa Fe **bridge design.** (2 800 words & fig.)

1932 621 .392 (.436) & 624 .32 (.436)
Engineering News-Record, No. 12, March 24, p. 439.
FALTUS (F.). — **Largest all-welded bridge** built in Czechoslovakia. (700 words & fig.)

1932 625 .1 (06 (.73)
Engineering News-Record, No. 12, March 24, p. 443.
Railway engineers discuss practice and economics. (3 900 word.)

1932 625 .24 (.73)
Engineering News-Record, No. 13, March 31, p. 471.
GRIFFIN (J. H.). — New York **subway construction** — VII — **Contracts and specifications.** (2 900 words.)

Indian Railway Gazette. (Calcutta.)

1932 625 .244
Indian Railway Gazette, March, p. 60.
Modern railway practice and development. Use of **refrigeration on railways.** (2 400 words.)

1932 347 .763 (.43)
Indian Railway Gazette, March, p. 64.
STRAUSS (F.). — **Regulations of road transport in Germany and Austria.** Laws in favour of State Railways. (1 800 words.)

1932 621 .43 (.82)
Indian Railway Gazette, March, p. 65.
330-B. H. P. Sulzer **Diesel locomotives** for the port of Rosario. (1 800 words & fig.)

Journal of the Institute of Transport. (London.)

1932 336 & 38
Journal of the Institute of Transport, March, p. 216.
HACKING (A.) & JEFFREYS (W. R.). — **Road finance in relation to general transport finance.** (13 300 words & table.)

1932 657
Journal of the Institute of Transport, March, p. 238.
DICKINSON (Sir A. L.). — The general principles of an efficient system of **transport accounting.** (24 000 words.)

1932 656
Journal of the Institute of Transport, March, p. 254.
UWINS (C. F.). — **Civil aviation** and its essential services. (8 000 words.)

1932 38
Journal of the Institute of Transport, April, p. 290.
BELL (R.). — The **effect of the « economic blizzard » on transport.** (14 000 words.)

1932 656 .253 & 656 .256
Journal of the Institute of Transport, April, p. 299.
BOUND (A. F.). — **Railway colour light signalling** in relation to **manual block and multiple aspect signals.** (48 000 words & fig.)

1932 38 (.82)
Journal of the Institute of Transport, April, p. 346.
Transport in the Argentine. (6 200 words & 2 tables.)

Locomotive, Railway Carriage and Wagon Review. (London.)

1932 621 .132.3 (.47)
Loc., Ry. Carr. & Wagon Review, March 15, p. 77.
« Prairie » type locomotives for the Russian Soviet Railways. (800 words & fig.)

1932 621 .43 & 625 .616
Loc., Ry. Carr. & Wagon Review, March 15, p. 82.
Diesel-electric locomotive for 2-ft gauge. (650 words & fig.)

1932 621 .43 (.42)
Loc., Ry. Carr. & Wagon Review, March 15, p. 83.
Trial run of the Armstrong **oil-electric rail-car** between Newcastle and Hexham, L. N. E. R. (750 words.)

1932 621 .133.4 (.44)
Loc., Ry. Carr. & Wagon Review, March 15, p. 88.
A French locomotive **spark arrester.** (350 words & fig.)

1932 621 .131.2
Loc., Ry. Carr. & Wagon Review, March 15, p. 90; April 15, p. 131.
PHILLIPSON (E. A.). — **Steam locomotive design : data and formulae.** (3 300 words.)

1932 621 .132.8 (.65)
Loc., Ry. Carr. & Wagon Review, March 15, p. 97.
Beyer-Garratt express locomotive for the Paris-Lyon & Mediterranean Railways. (Algeria). (450 words & fig.)

1932 621 .138.2 (.42)
Loc., Ry. Carr. & Wagon Review, March 15, p. 98.
Coaling plant at Cudworth locomotive sheds, L. N. E. Ry. (400 words & fig.)

1932 621 .135.2 (.54)
Loc., Ry. Carr. & Wagon Review, March 15, p. 99.
Cortazzi **radial axleboxes** Gwalior Light Rys. locomotives. (450 words & fig.)

1932 621 .133.3
Loc., Ry. Carr. & Wagon Review, March 15, p. 102.
Improved « Diamond » **soot cleaner for locomotives.** (400 words & fig.)

1932 621 .335
Loc., Ry. Carr. & Wagon Review, March 15, p. 108; April 15, p. 132.
Electric locomotive design : IV. (300 words & fig.)

1932 621 .132.5 (.47)
Loc., Ry. Carr. & Wagon Review, March 15, p. 115.
Recent **Russian locomotives.** (2 000 words & fig.)

1932 621 .132.3 (.54)
Loc., Ry. Carr. & Wagon Review, April 15, p. 117.
Standard « YC » type **metre gauge locomotives,** Madras & Southern Mahratta, and Burma Railways. (1 100 words & fig.)

1932 621 .335 (.41)
Loc., Ry. Carr. & Wagon Review, April 15, p. 120.
Drumm **battery electric motor coach,** Great Southern Railways of Ireland. (1 600 words & fig.)

1932 621 .43 (.54) & 625 .232 (.54)
Loc., Ry. Carr. & Wagon Review, April 15, p. 136.
Articulated carriages on the Nawanagar State Tramway, India. (400 words & fig.)

1932 621 .134.1 & 669
Loc., Ry. Carr. & Wagon Review, April 15, p. 142.
Centrifugal castings for liners, etc. for locomotive cylinders. (1 700 words & fig.)

Mechanical Engineering. (New York.)

1932 621 .116
Mechanical Engineering, April, p. 256.
Coal and its competitors. (5 800 words & fig.)

1932 385. (072 & 532
Mechanical Engineering, April, p. 263.
EATON (H. N.). — The national hydraulic laboratory. (2 400 words & fig.)

1932 613
Mechanical Engineering, April, p. 271.
FIRESTONE (F. A.), DURBIN (F. M.) & ABBOTT (E. J.). — Reducing noise of machines. (4 000 words & fig.)

1932 536
Mechanical Engineering, April, p. 275.
KING (W. J.). — The basic laws and data of heat transmission. (3 000 words & fig.)

Modern Transport. (London.)

1932 656 .253 (.42)
Modern Transport, No. 679, March 19, p. 3.
BOUND (A. F.). — Colour-light signals. Suggested standard practices for British Railways. (6 900 words & fig.)

1932 656. (0
Modern Transport, No. 679, March 19, p. 7.
SHERRINGTON (C. E. R.). — Recent developments in foreign railways. (1 400 words & 1 table).

1932 621 .43
Modern Transport, No. 679, March 19, p. 8.
CHORLTON (A. E. L.). — Oil-engine traction. No. 2. Problems of transmission and the systems employed. (1 800 words.)

1932 385. (091 (.42)
Modern Transport, No. 679, March 19, p. 9.
MAULDIN (H. H.), — Railway progress in Great Britain. New methods of operation. (2 300 words.)

1932 38 (.42) & 656 .1 (.42)
Modern Transport, No. 679, March 19, p. 19.
Traders and the railway manifesto. — Advantages of privately-owned fleets. (2 000 words.)

1932 625 .245 (.42)
Modern Transport, No. 680, March 26, p. 3.
Exceptional loads by rail. L. N. E. R. Carries 110-ton consignments. (900 words & fig.)

1932 656 .1 (.42)
Modern Transport, No. 680, March 26, p. 5.
Railway Companies and road competition. (2 000 words.)

1932 656 .23 (.42)
Modern Transport, No. 680, March 26, p. 6.
Industrial traffic management. No. 21. — Exceptional railway rates. (1 000 words.)

1932 656 .1 (.42)
Modern Transport, No. 680, March 26, p. 9.
Taxation of motor vehicles. — Memorandum to Chancellor of Exchequer. (1 600 words.)

1932 656 .253 (.42)
Modern Transport, No. 681, April 2, p. 3.
Speed signalling on the L. M. S. Ry. (1 400 words & fig.)

1932 656 .1 (.42)
Modern Transport, No. 681, April 2, p. 5.
Railway-operated road transport. Progressive policy of the G. W. Ry. (2 000 words.)

1932 625 .245 (.42)
Modern Transport, No. 681, April 2, p. 7.
New wagons for London Underground Railways. (500 words & fig.)

1932 656 .261 (.42)
Modern Transport, No. 681, April 2, p. 8.
Industrial traffic management. No. 22. — Collection and delivery. (1 300 words.)

1932 656 .225
Modern Transport, No. 681, April 2, p. 9.
Cost of international transport. Reduction by use of containers. (900 words.)

1932 625 .175 (.68)
Modern Transport, No. 682, April 9, p. 3.
Petrol-driven inspection cars. Converted road vehicles in South Africa. (1 000 words & fig.)

1932 656 .253
Modern Transport, No. 682, April 9, p. 5.
Multiple-aspect signals. (2 300 words.)

1932 621 .13 & 625 .2
Modern Transport, No. 682, April 9, p. 6.
Railway passenger rolling stock. Design and operation. (2 000 words.)

1932 656 .1 (.43)
Modern Transport, No. 682, April 9, p. 7.
Co-ordination of rail and road services. Developments in Germany and Austria. (2 900 words.)

1932 625 .232 (.493)
Modern Transport, No. 682, April 9, p. 9.
New rolling stock for Belgium. (500 words.)

1932 656 .23 (.42)
Modern Transport No. 683, April 16, p. 3.
WHEELER (G. H.). — **Merchandise traffic by rail. Origin** and application of the **classification.** (1 900 words.)

1932 621 .43 (.43)
Modern Transport, No. 683, April 16, p. 5.
Passenger handling methods in Germany. No. 1. — **Internal combustion rail cars.** (3 000 words.)

1932 625 .236 (.42)
Modern Transport, No. 683, April 16, p. 7.
London Midland & Scottish Ry. **train-washing apparatus.** (250 words & fig.)

1932 385 .3 (.73) & 656 .1 (.73)
Modern Transport, No. 683, April 16, p. 12.
Road transport in the United States. How **competition** has affected the Railways. (1 900 words.)

Railway Age. (New York.)

1932 656 .211.4 (.73)
Railway Age, No. 10, March 5, p. 390.
Boston & Maine completes large **terminal** project at Boston. (5 400 words & fig.)

1932 621 .139 (.73)
Railway Age, No. 10, March 5, p. 396.
WALTER (E. W.). — How the Baltimore & Ohio **handles scrap.** (4 000 words & fig.)

1932 621 .335 (.73) & 621 .43 (.73)
Railway Age, No. 10, March 5, p. 401.
Rail cars runs on pneumatic tires. (2 700 words, 1 table & fig.)

1932 625 .258 (.73)
Railway Age, No. 10, March 5, p. 405.
Retarders in Potomac yard facilitate movement of perishables. (1 100 words, 1 table & fig.)

1932 621 .133.3 (.73)
Railway Age, No. 10, March 5, p. 407.
Nalco continuous **blow-down** system. (600 words & fig.)

1932 621 .335 (.73) & 621 .43 (.73)
Railway Age, No. 10, March 5, p. 411.
HAMILTON (W. S. H.). — Performance of **three-power locomotives.** (3 000 words & fig.)

1932 656 .223.1 (.73)
Railway Age, No. 11, March 12, p. 429.
BLACK (R. A.). — **Heavier loading** means profit. (900 words & fig.)

1932 625 .234 (.73)
Railway Age, No. 12, Mach 19, p. 431.
Baltimore & Ohio extends use of **air conditioning.** (1 300 words & fig.)

1932 621 .132.5 (.73)
Railway Age, No. 12, March 19, p. 469.
LYFORD (F. E.). — Lehigh Valley tests 4-8-4 type **locomotives.** (1 400 words, 5 tables & fig.)

1932 347 .763 (.73)
Railway Age, No. 12, March 19, p. 475.
Railways give views on **motor regulation.** (2 800 words.)

1932 656 .258 (.73)
Railway Age, No. 12, March 19, p. 477.
Automatic and remote control applied to junction interlocking on Great Northern. (1 500 words & fig.)

1932 625 .1 (06 (.73)
Railway Age, No. 12, March 19, p. 481.
A. R. E. A. holds its thirty-third **convention** (15 & 16 March 1932). (25 000 words.)

1932 625 .245 (.73) & 625 .246 (.73)
Railway Age, No. 12, March 19, p. 516.
Aluminium placed on trial in **hopper cars.** (2 000 words & fig.)

1932 385 .3 (.73)
Railway Age, No. 13, March 26, p. 520.
PORTER (C. R.). — A reply to critics of the **Interstate Commerce Commission.** (3 900 words.)

1932 691
Railway Age, No. 13, March 26, p. 523.
VAN NESS (R. A.). — A long time record in **timber preservation.** (1 900 words & fig.)

1932 656 .1 (.42) & 656 .261 (.42)
Railway Age, No. 13, March 26, p. 533.
British road offers complete service. (1 200 words & fig.)

1932 625 .111 (.73)
Railway Age, No. 14, April 2, p. 556.
SKILLMAN (T. J.). — A new attitude is needed toward **grade crossing separation.** (2 900 words & fig.)

1932 621 .335 (.73) & 621 .43 (.73)
Railway Age, No. 14, April 2, p. 559.
Sixty-ton **gas-electric locomotive (light switching, terminal and mixed -train work)** tested on the Burlington. (1 500 words & fig.)

1932 656 .222 (.73)
Railway Age, No. 14, April 2, p. 561.
The **fastest freight train.** (2 200 words & fig.)

1932 621 .43 (.73)
Railway Age, No. 15, April 9, p. 602.
O' BRIEN (R. J.). — **Oil-electric car** in mixed train service. (800 words & fig.)

1932 625 .246 (.73)
Railway Age, No. 15, April 9, p. 605.
General American develops **tank car for dry commodities.** (2 000 words & fig.)

1932 656 .255 (.73)
Railway Age, No. 15, April 9, p. 609.
Baltimore & Ohio installs centralized traffic control. (3 000 words & fig.)

Railway Engineer. (London.)

1932 625 .143.4
Railway Engineer, April, p. 128.
WILDT (S.). — Rigidity of long rail track. (3 300 words, 2 tables & fig.)

1932 621 .335 (.494)
Railway Engineer, April, p. 132.
New 7 500 H. P. 1-B-1-B-1 + 1-B-1-B-1 single phase mixed traffic locomotives for service on the St. Gothard line, Swiss Federal Rys. (4 400 words & fig.)

1932 621 .334 (.42)
Railway Engineer, April, p. 139.
Mobile trucks for railway use. — IV. (1 400 words & fig.)

1932 621 .132.3 (.44) & 621 .132.5 (.44)
Railway Engineer, April, p. 146.
Modern locomotive practice on the Northern Railway of France. (1 200 words & fig.)

1932 621 .335 (.41)
Railway Engineer, April, p. 149.
Battery electric traction in Ireland. (2 400 words.)

1932 625 .114
Railway Engineer, April, p. 151.
HIGGINS (A. L.). — A simplified method of railway cross-sectioning. (1 800 words & fig.)

1932 621 .332 & 621 .323
Railway Engineer, April, p. 154.
OLLIVER (C. W.). — Traction motors and rectifiers. (2 000 words & fig.)

1932 625 .144 (.44) & 625 .17 (.44)
Railway Engineer, April, p. 156.
Track maintenance by measured shovel packing. (2 400 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1932 625 .143.3 (.73) & 625 .246 (.73)
Railway Engineering and Maintenance, April, p. 252.
BRONSON (C. B.). — New York Central's new rail flaw detector now in service. (3 500 words & fig.)

1932 621 .133.7 (.73) & 725 .33 (.73)
Railway Engineering and Maintenance, April, p. 256.
How the Texas and Pacific Railroad has improved its water supply. (5 000 words & fig.)

1932 721 .1 (.73)
Railway Engineering and Maintenance, April, p. 261.
JUDD (F. R.). — Why not use creosote piles for building foundations? (2 000 words & fig.)

1932 625 .123 (.73)
Railway Engineering and Maintenance, April, p. 263.
Drainage system pays return of 15 per cent. (1 100 words & fig.)

1932 625 .143.3 (.73)
Railway Engineering and Maintenance, April, p. 265.
BALDRIDGE (C. W.). — Are defective rails safe? (1 900 words & fig.)

1932 625 .15 (.73)
Railway Engineering and Maintenance, April, p. 267.
Why use guard rails on bridges? (2 700 words & fig.)

Railway Gazette. (London.)

1932 656 .1 (.42)
Railway Gazette, No. 12, March 18, p. 423.
Railways and road competition. (2 800 words.)

1932 621 .91 (.68)
Railway Gazette, No. 12, March 18, p. 425.
New machine tools for railway workshops. (500 words & fig.)

1932 656 .212.9 (.42)
Railway Gazette, No. 12, March 18, p. 426.
A new London railhead distribution depôt. (1 000 words & fig.)

1932 621 .33 (.82)
Railway Gazette, No. 12, March 18, p. 428.
Electrified suburban system of the Central Argentine Railway. (2 900 words & fig.)

1932 624 .62 (.944)
Railway Gazette, No. 12, March 18, p. 431.
The Sydney harbour bridge. (2 300 words & fig.)

1932 656 .253 & 656 .256
Railway Gazette, No. 12, March 18, p. 442.
Railway Colour light signalling in relation to manual block and multiple-aspect signals. (2 600 words & fig.)

1932 656 .234 (.42)
Railway Gazette, No. 13, March 25, p. 459.
ARNOLD (W. C.). — Penny transport. (3 800 words.)

1932 624 .32 (.68)
Railway Gazette, No. 13, March 25, p. 462.
Important New South African bridge. (500 words & fig.)

1932 621 .43
Railway Gazette, No. 13, March 25, p. 463.
Diesel railway traction section. (1 700 words.)

1932 621 .43
Railway Gazette, No. 13, March 25, p. 464.
Sleeve-valve Diesel engines for rail traction. (700 words & fig.)

1932 621 .13 & 621 .43
Railway Gazette, No. 13, March 25, p. 465.
Diesel shunting locomotives. (350 words.)

1932 621 .43 (.489)
Railway Gazette, No. 13, March 25, p. 466.
Running costs for **Danish Diesel stock.** (600 words & fig.)

1932 621 .335 (.43) & 621 .43 (.43)
Railway Gazette, No. 13, March 25, p. 467.
German **high-speed Diesel-electric railcar.** (600 words & fig.)

1932 621 .43
Railway Gazette, No. 13, March 25, p. 468.
REED (B.). — The **heavy-oil engine for rail traction.** A brief general survey. (800 words & 1 table.)

1932 621 .43 (.42)
Railway Gazette, No. 13, March 25, p. 469.
Hunslet **Diesel shunting locomotive.** (1 100 words & fig.)

1932 621 .43
Railway Gazette, No. 13, March 25, p. 471.
NIALL (S.). — **Transmissions for Diesel locomotives and railcars.** (2 000 words & fig.)

1932 654 (.45)
Railway Gazette, No. 14, April 1, p. 491.
Printing telegraph installations, Italian State Rys. (1 200 words & fig.)

1932 656 .261 (.42)
Railway Gazette, No. 14, April 1, p. 494.
Furniture removals by rail. (1 300 words & fig.)

1932 621 .132.6 (.82)
Railway Gazette, No. 14, April 1, p. 499.
« **Sentinel** » locomotive for Argentine suburban services. (1 000 words & fig.)

1932 656 .255 (.42)
Railway Gazette, No 15, April 8, p. 521.
Single line token instruments. (600 words & fig.)

1932 656 .222.6 (.42)
Railway Gazette, No. 15, April 8, p. 523.
Great Western Railway **accelerated freight train services.** (1 400 words & fig.)

1932 621 .132.3 (.44)
Railway Gazette, No. 15, April 8, p. 524.
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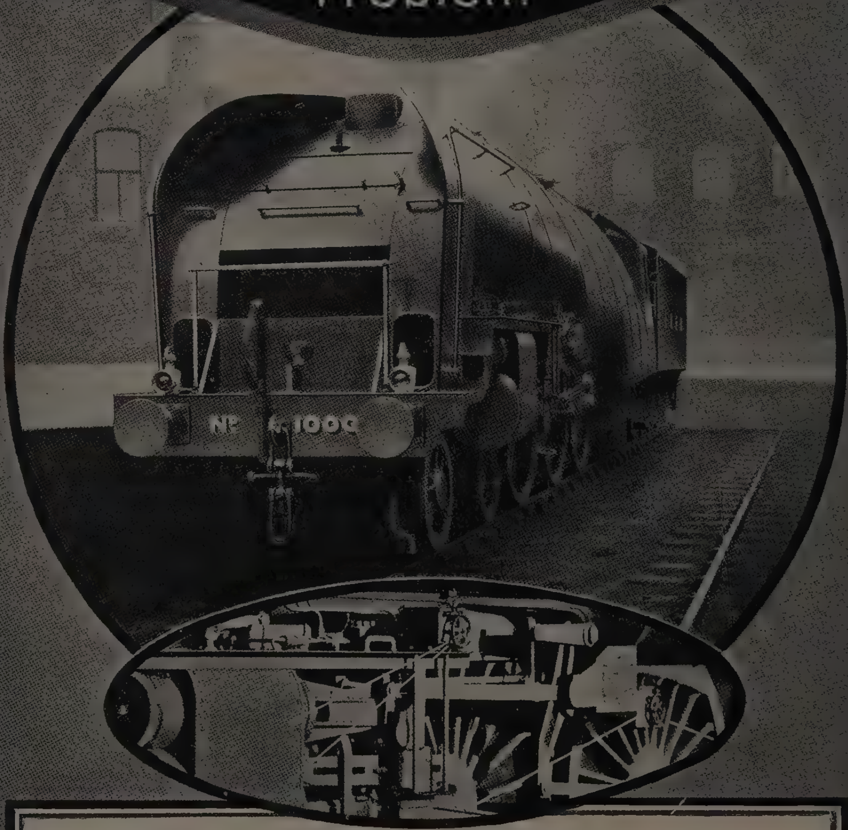

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